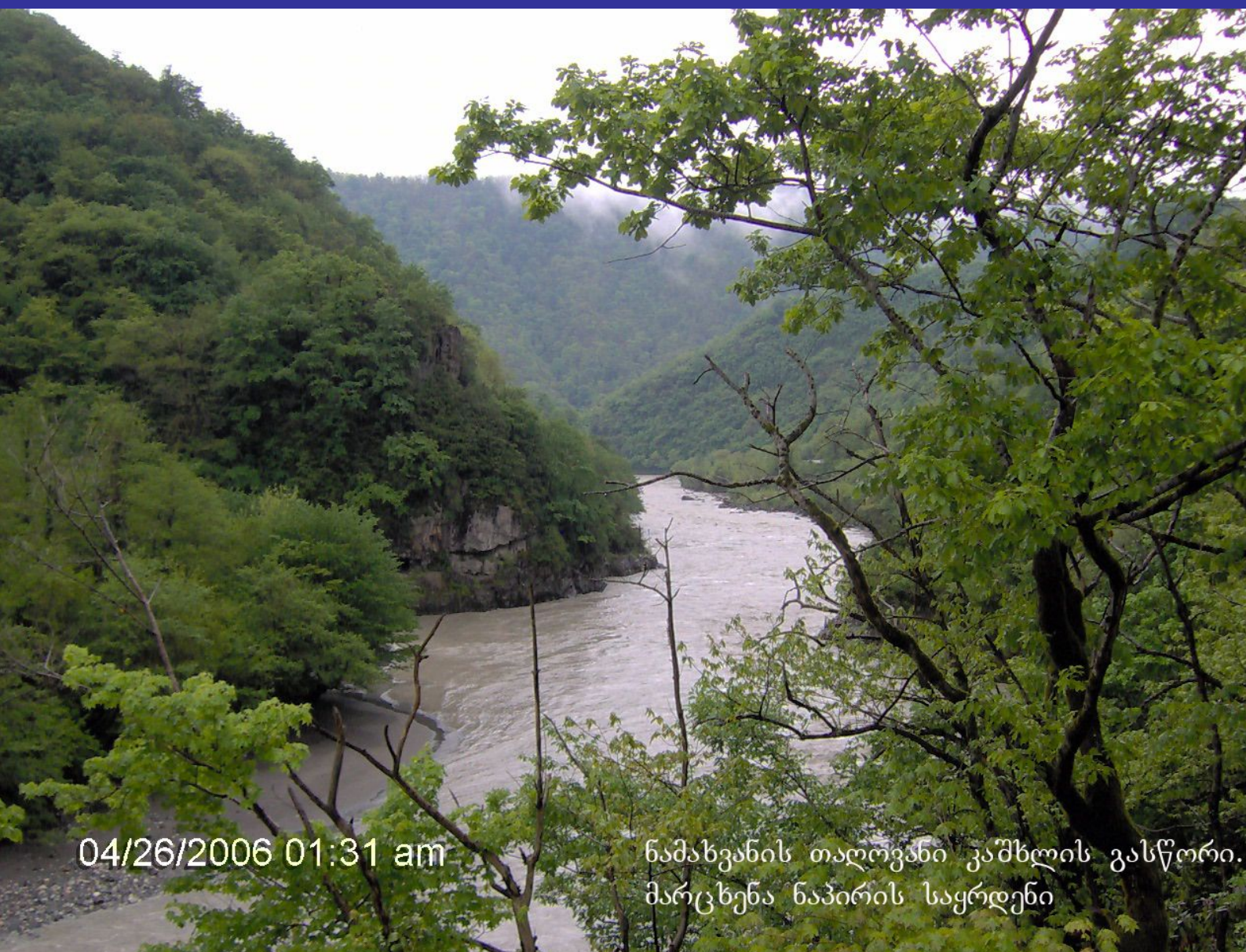


PRE-FEASIBILITY REVIEW OF NAMAKHVANI CASCADE OF HYDRO POWER PLANTS

Advisory Assistance to the Ministry of Energy of Georgia
P.E.D. IQC – Contract No. DOT-I-00-04-00020-00 Task Order # 800



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მარცხენა ნაპირის საყრდენი

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Disclaimer

The author's views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

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EXECUTIVE SUMMARY

This pre-feasibility study introduces Georgia's Namakhvani Cascade of Hydro Power Plants project concept as a potential investment opportunity. The study provides a short history of Namakhvani HPP construction, information regarding the initial design decisions and subsequent revisions to improve environmental impacts, a brief summary of technical characteristics of the project, and a short overview of current conditions. We also give a general economic assessment of the project.

The Namakhvani HPP Cascade is one of several large to medium hydro power generation facilities planned under the Soviet Union, to use the large hydro power generation capacity of the rivers in western Georgia. Construction was halted for a combination of political and financial concerns. The proven feasibility of use of the Rioni River flow for hydro power generation, together with the currently expected 450 MW peak capacity potential of Namakhvani cascade, have generated recurring interest in completion of the Cascade.

The essential economic result of this analysis is that Namakhvani HPP Cascade could be financed if it were sold largely to the export (regional market), and/or if generation prices within Georgia were substantially higher than at present. However, the plant adds a significant volume of energy generation capacity and thus together with the existing hydro power plants on Rioni river, enables much better system operation in winter months and substantial energy exports (especially in summer) from Georgia in excess of the country's domestic load.

The study is based on such existing materials as we were able to locate, a visual inspection of the facilities, discussions with knowledgeable persons, and our own model of potential Namakhvani HPP Cascade operations in the Georgian power system. None of the sources were verified, and we have made no attempt to re-compute any of the analyses, nor to assess the data and analysis contained in them. Our very preliminary estimates of the economic characteristics of the Namakhvani HPP Cascade are based on the best data available to us, but we have not audited those sources.

INTRODUCTION

Georgia is believed to have a very large hydro power generation potential, estimated at up to 80 billion kWh annually, of which about 10 billion kWh is attributable to smaller rivers. Georgia currently has about 60 larger and smaller capacity power stations with an annual maximal output capability of about 8.5 billion kWh. That is, less than 11% of the theoretically usable hydro potential is currently used. At the same time, countries in the region (especially Turkey, Iran and possible further south) are generally believed to be experiencing rapid economic growth and thus to offer large potential demands for electric power capacity and energy. When the Caucasus region, including Georgia, was part of the Soviet Union, the Georgian grid formed part of Southern Caucasus regional power system (united grid of three Caucasus republics – Armenia, Azerbaijan and Georgia), which often operated independently from the Russian grid. Georgian hydropower was used to cover peak demands while Armenia's nuclear and Azerbaijan's thermal power plants carried base load of the regional system. After the break up of Soviet Union each country started to operate its power system independently. As a result Georgia was left with insufficient power generation for the winter period, due to lack of water in rivers in winter. As for thermal power generation – it was always more expensive and problematic to arrange for uninterrupted fuel supply for the plants.

One of the solutions to this is increasing hydro power generation in Georgia. The Namakhvani Hydro Power Plant Cascade project was one of several major projects (along with Khudoni HPP project on Enguri River) originally conceived in the Soviet period that would add to Georgia's hydro generation capacity.

1. SHORT HISTORY OF THE PROJECT

1.1. History of Design and Project Approvals

First feasibility study (TEO: technical-economic justification) for construction of 570 MW of two-step hydro power plant, with average annual generation of 1840 million kWh, was approved by the Ministry of Energy of the USSR on May 17, 1972 and later accepted by the State Construction and Planning Committee of the former USSR in 1974. ([APPENDIX 1 – Copy of Letter #MF-1550-20/5, dated April 12, 1974](#)). In 1975 the Ministry of Energy of the USSR instructed the “TbilHydroProject” - Tbilisi branch of Soviet Union's Hydro Design Institute named after S.Ya. Zhuk to develop a technical project for construction of a two-step Namakhvani HPP ([APPENDIX 2 – Technical Assignment #79, dated September 17, 1975](#)).

The geological and ecological surveys conducted in the course of preparation of the technical project design revealed an initial problem which had to be resolved: a danger of landslides caused by the changes of water level in the reservoir. The most serious risk was that the stability of so called Goni massif, located on the left bank of the reservoir. The potential total volume of landslide can reach 30-60 million m³. A landslide of this scale would inevitably block the river in the reservoir and lead to a disaster when later the water would break through the barrier. Thus the Hydro Design Institute decided to revise the project. Instead of construction of a two-step cascade with 360 m. water level, the Institute proposed not to accumulate water in the area of landslide risk and to lower the water level, leaving the remaining fall of the water for an additional – third step of the cascade.

The two-step cascade had other problems. The more serious argument against the project was flooding of land in one of Georgia's most productive agricultural regions. As there was no other land available nearby, flooding would cause resettlement of many families from the reservoir zone to other regions of the country. The three-step project reduces the resettlement problem and necessity to flood vineyards with precious species of vine – “Tvishi”. In course of research and design work several different options of three-step cascade was reviewed and compared.

In 1984 the first three-step project with total capacity of 400 MW was agreed with the State Construction Committee of Georgia ("Sakhmsheni") and with the Cabinet of Ministers of Georgia ([APPENDIX 3 – Sakhmsheni Letter #ПЛ-497-3 dated 23.04.1984; Cabinet of Ministers' Decree #342, dated 25.05.1984](#)). In 1986 first stage of the project for three-step Namakhvani Cascade - Tvishi HPP, Namakhvani HPP and Zhoneti HPP was approved by the Ministry of Energy of the USSR and consent was given to TbilHydroProject to start development of technical documentation for the preparatory stage of construction ([APPENDIX 4 - Order # 35ПC, dated 12.02.1986; Letter # M-244-14, dated 27.05.1986](#)).

The final 450MW version of Namakhvani HPP Cascade project was agreed with the Cabinet of Ministers of Georgia in 1987 ([APPENDIX 5 – Project Approval by the Cabinet of Ministers, dated 23.12.1987](#)). At the same time TbilHydroProject submitted the project for expertise to the Department of Project Expertise and Cost Estimate of the Ministry of Energy of the USSR and received a positive conclusion. In compliance with the above conclusion and consent from the State Planning Committee of the USSR on inclusion of the project in Soviet Union's construction plan, the Ministry of Energy and Electrification of the USSR issued approval for construction of the three-step Namakhvani Cascade of Hydro Power Plants on Rioni river ([APPENDIX 6 – GosPlan's Letter #CB-150/39-219, dated 21.03.1988; MinEnergy's Order #294ПC, dated 21.12.1988](#)), with following main parameters:

#	Parameter	Tvishi	Namakhvani	Zhoneti	Total
1	Installed capacity (MW)	100	250	100	450
2	Normal water level of the reservoir (m)	360	310	232	-
3	Volume of the reservoir (million m ³)				
	Total	13.1	156.0	12.6	-
	Useful	1.8	52.0	6.0	
4	Average annual generation (million kWh)	400.0	928.0	346.0	1674.0
5	Total construction cost in 1984 year prices (million Rubles)	-	-	-	386.88
6	Duration of construction (years)	-	-	-	7.3

1.2.Start and Suspension of the Construction

SakEnergo (Main Department for Management of Energy Sector and Electrification of Georgian SSR under the Ministry of Energy and Electrification of the USSR) designated Vartsikhe HPP Cascade Management as a Client in construction of Namakhvani HPP Cascade ([APPENDIX 7 – SakEnergo's Order #181, dated 12.04.1988](#)). In 1988 TbilHydroProject developed the technical documentation and submitted it to the client. Complete project design documentation consists of 125 volumes (including attached volumes of sub-contractors' research results – some of them stored only at TbilHydroProject archive) and is divided into ten parts:

Part #	Description of Content	Number of Volumes
Part I	– General Information	4
Part II	– Natural Conditions	5
Part III	– Water Facilities. Justification of Design and Economic Effectiveness of the Hydro Power Plants	3
Part IV	– Main Structures	47
Part V	– Organization of Plant Operations	1
Part VI	– Reservoirs. Protection of Environment	26
Part VII	– Housing Architecture and Construction	2
Part VIII	– Organization of Construction Works of Hydro Power Plant	17
Part IX	– Financial Calculations and Budget Documentation	19
Part X	– Launch Complex	1
		<hr/> 125

See [APPENDIX 10 – Project Documentation – Tables of Contents from Selected Volumes](#). One set of all documentation (including surveys and field research results of other sub-contracted institutes and organizations) is still stored in the archive of TbilHydroProject Institute.

Financing of the construction started in 1988 through Georgian branch of the State Construction Bank of USSR “Sakhmshenbanki” ([APPENDIX 8 – Copy of Letter #04-400, dated 21.03.1988](#)). During preparatory construction works in 1988-89 access roads and some construction facilities were started and some of them completed.

Financing and consequently construction of the project ceased in 1989. Soviet Union was falling apart and respectively all its structures and bodies were wrapping up their operations. Based on the instructions from the Ministry of Energy and Electrification of the USSR and State Construction Bank of USSR, SakEnergo issued an order on suspension of works on Namakhvani HPP project from July 1, 1989 ([APPENDIX 9 – Copy of SakEnergo’s Order #409, dated 2.11.1989](#)).

At a later time (in 1992), after suspension of the construction, “SakEnergo” issued a technical instruction to TbilHydroProject Institute to separate the Tvishi HPP as an independent facility and to redesign the project in compliance with modern environmental standards. The main argument stimulating the interest was the acute deficit of electricity in Georgia in that period and possibilities of using abundant “almost free” hydro resources in the country. As construction of Tvishi HPP with smaller reservoir in the Namakhvani Cascade would bring practically no harm to the surrounding environment, “TbilHydroProject” promptly developed separate construction documentation for the plant. Unfortunately, due to lack of funding no further action was taken on any of the abovementioned projects.

2. TECHNICAL DESCRIPTION OF THE PROJECT

Namakhvani HPP Cascade (consisting of Tvishi HPP, Namakhvani HPP and Zhoneti HPP) is situated in Western Georgia and is designed for operation in the energy system of Georgia. Namakhvani HPPs use the drop of Rioni river, existing between the pools of Lajanuri HPP and Gumati HPP (between of 360.0 and 200.0 m marks). See [APPENDIX 11 – Drawings – General Plans](#).

The normal water level in the reservoir of the Tvishi HPP, at the upper step of Namakhvani Cascade, is 360 m. The total reservoir volume of the plant is 13.1 million m³. Sediment will completely fill it in 1.5 years. The research results showed that if special cleaning measures are taken and the upstream area is washed out periodically, active volume of 1.8 million m³ of the reservoir can be preserved and plant can be used for limited daily regulation purposes in the power system. Engineering calculations showed that Tvishi HPP is limited to daily regulation and two power unit scheme with total installed capacity of 100 MW.

The normal water level of the Namakhvani HPP reservoir is 310 meters with optimum drop of water level in the reservoir 12 m. The total volume of the reservoir equals 156 million m³ and useful – 52 million m³. Installed capacity of the plant is 250 MW and it is designed for seasonal regulation.

The normal water level of the Zhoneti HPP reservoir is 232 meters with total volume of 12.5 million m³ and useful – 6.0 million m³. The reservoir is for daily regulation and installed capacity of the Zhoneti HPP is 100 MW.

Table 1. MAIN PARAMETERS OF THE PROPOSED NAMAKHVANI CASCADE HPPs

Parameter	Unit of Measure	Tvishi HPP	Namakhvani HPP	Zhoneti HPP
Watershed (Basin)	km ²	3220	3425	3520
Duration of Hydro-Meteorological Monitoring	Years	55	55	55
Annual Run of Water	Million m ³	4860	4910	4980
Characteristic Water Flow Rates:				
a) Multi-Year Average	m ³ /sec	154	156	158
b) Maximum with 0.01% Provision	m ³ /sec	3630	3700	3700
Reservoir Parameters:				
a) Normal Water Level	m	360	310	232
b) Water Surface Area	km ²	0.74	4.9	1.25
c) Water Level Drop	m	3	12	6
d) Total Volume	Million m ³	13.1	156	12.5
e) Useful Volume	Million m ³	1.8	52.0	6.0
Regulation Type	-	Limited Daily	Seasonal	Daily
Water Head				
a) Maximum	m	36.8	83.6	32.0
b) Normal	m	33.3	75.5	27.0
c) Minimum	m	30.0	64.5	24.4
Normal Water Flow Rate	m ³ /sec	336	366	416
HPP Capacity				
a) Installed	MW	2x55 = 100	2x125 = 250	2x55 = 100
b) Guaranteed	MW	9	26.3	6
Average Annual Generation	million kWh	403.5	928.0	346.0
Duration of Operation at Average (multi-year) Installed Capacity in a Year	hours	4035	3712	3460

2.1. HYDROLOGY AND CLIMATE

The Rioni River is the biggest river in the West Georgia. The river head is located in the glaciers of the main Caucasian mountain range, in the "Pasi" mountain area (the mountain peak is at 3785 m level). The river flows into the Black Sea near Poti. Systematic study of the Rioni River started in 1909. Large amount of data was collected during 55 years of uninterrupted hydrological observations (from 1931 to 1986) and in the long history of development of its resources. There are 8 big hydro power plants built at various times on Rioni River: Lajanuri HPP (upstream from proposed Namakhvani Cascade site), Gumati I & II HPPs, Rioni HPP and Vartsikhe I, II, III & IV HPPs.

The river sources are mixed: glaciers, snow, rain and round water. The river regime characteristics are: spring increase occurs in the middle of March; reaching maximum level - in May-June; final reduction – August-September; and summer/autumn flood due to rains. The total area of the river watershed is 13418 km², while near the Namakhvani HPP area (25 km upstream from Kutaisi) - 3425km². The total length of the river is 327 km. The river length from the head till the Namakhvani HPP is 148 km. The average annual run of the river equals 4.9 million m³ and average annual water flow – 127 m³/sec.

The climate at the proposed construction site is mildly warm and wet. Average annual temperature equals 13.8°C; absolute minimum is minus -16°C in winter and absolute maximum – 40°C in August. Average level of annual precipitation at Namakhvani village is 1695 mm. According to the data of the Namakhvani village Hydro meteorological Station the South winds prevail. The next most frequent wind direction is East wind. Average wind velocity is 2.1 m/sec, maximum – 12-13 m/sec. Average annual evaporation is 718 mm. Maximum snow level during observation period equals 130 cm.

Near the Namakhvani village the run of the river of the Rioni River is 156 m²/sec when the Shaori and Lajanuri HPPs are operating.

Maximum water discharge in case of 0.01% provision is 3700 m³/sec at the Namakhvani HPP and 3630 m³/sec at the Tvishi HPP.

Estimated volume of solid sediments brought by the river is 8.91 million m³ at Namakhvani HPP, and 7.26 million m³ – at Tvishi HPP.

2.2.ENGINEERING GEODESIC SURVEYS

Available maps of this region are 1:25000 and 1:50000 scale maps. In the past, before 1984, the old maps were corrected and bigger scale maps developed for the territory where the main and auxiliary structures would be located.

Topographical air photos were taken at 1:1000 scale. 1:1000 scale maps were developed for Tvishi and Zhoneti HPP territories.

Maps were also developed for the temporary settlement, sand pits, automobile road etc.

2.3.MAIN STRUCTURES AND BUILDINGS

2.3.1. Tvishi HPP

The Tvishi HPP is the first (upper) step of the cascade that will use the river Rioni fall between 360.00 m and 322.00 m levels. The Tvishi HPP dam is located in the narrow canyon near the Tvishi village of Tsageri region. The total area of the watershed of the Rioni River before the dam is 3425 km².

Engineering/geological parameters are convenient for the HPP construction. The ground of the Rioni valley consists of layers of lime and inter-strata quartz. The rocks are hard and not karstic. The river bed is filled with alluvial sediments of 17-18 meter width. According to the new seismic map of Georgia the construction site is located within the Richter 8 level zone ([APPENDIX 15 – Simplified Map of Seismic Zoning of Georgia](#)).

The power plant is located near the dam. The main structures of the Tvishi HPP include: concrete gravity dam, construction tunnel, to be used as a derivation tunnel later, water intake, the power plant building, 220 kV open switchyard and downstream spillway chamber. All structures belong to the 3rd class of capital construction standards. See [APPENDIX 12 – Drawings – Tvishi HPP](#).

The crown of the concrete dam is at 361.50 m level, forming the reservoir of 13.1 million m³ capacity, where the normal water accumulation level is at 360.00 m. The dam consists of spillways and solid parts. The spillway is 54 m long. Its width is 50 m. The bottom of the dam will be located in the alluvion and in the central part deepens down to 306.00 m level. The pressure face of the dam is vertical, with a console header. The lower face is of non-vacuum practical profile. Its margin is located at 345.00 m level. The spillway consists of three sections, each 14 m long. The dam is designed to pass maximum flow in case of 0.1% provision, i.e. 1974 m³/sec considering that the flow rate of water passing through the power plant is 336 m³/sec. In order to regulate the upstream water level, 14-15.3-15.0 flat paired locks will be installed in the spillway

of the dam. The locks will be operated by means of a stationary hoist that can lift 150 tons. The section lock used during repairs – 14.0-15.4-15.0 is operated by means of 2x25 ton frame crane. It is planned to arrange a dissipating well in the downstream area. A drainage gallery (12.5 x 3.0 m) will be arranged in the blank part of the dam. Later it will also be used for inspections. The blank part of the dam gets into the rock located along the river bank. There will be a cement curtain at the bottom of the dam, along the whole underground perimeter.

In order to remove water from the dam cavity during the construction, a construction tunnel will be built on the left bank of the Rioni River. After the construction of the dam is over and the tunnel plugged up, its 309.35 m long middle section can be used as derivation tunnel, in combination with the water intake and two short branches of the head-race tunnel.

The total length of the construction tunnel is 525.65 m. The tunnel is designed for 10% provision of the flow rate during the construction, which is 1100 m³/sec. The bias of the lower part of the tunnel is 1=0.01. The cross-section of the tunnel portal is 10x10m, while the threshold is located at 327.55 m level. The lining of the tunnel surface is 0.5 m.

Flat sliding locks 10-12.3-32.45 located in the tunnel entrance will have notches.

Water intake borders with the left side of the spillway of the dam forming 120° angle. The water intake is designed for 336 m³/sec assumed flow rate. It will have locks for repair 7.5-10.4-10.0. The notches of the repair locks will have 4 fenders of 7.5x10.0x2.0 size to protect them from penetration of floating wastes. The fenders will be cleaned by means of clam-shells. The locks will be operated by means of a frame crane and beam of 50 ton bearing capacity.

6.5-6.5-18.25 locks meant for emergency situations and repairs will be installed in the entrance of the derivation tunnels. They will be operated by means of 50 ton stationary hoist. At 350.00 m level the water intake threshold is located from which two pressure derivation tunnels start. The tunnel diameter is 6.5, the lining is 0.5 m wide and the tunnel length is 51.0 m. The tunnels pass through the main rocks.

Near the open HPP building the tunnel diameter is decreasing down to 5.75 m and the concrete facing is strengthened by means of metal lining. The size of the HPP building is 17.0 x 60.70 m, the height – 51.0 m. Two units, 50 MW each, will be installed in the HPP building.

Estimated water flow rate through the turbine - 168 m³/sec.

Average annual generation – 403 million kWh.

The turbine axis is at 319.60 m level, the floor of the machine room – at 332.00 m level.

A frame crane of 350/80 ton bearing capacity will be installed in the HPP building. The size of assembly field, located to the left of Unit 1, will be 17.0 x 28.15. The equipment will be delivered to the assembly field by means of automobile road.

The Kharkov Turbine Factory has developed the design for the type of turbines needed for Tvishi HPP. The turbine type is ПЛ40-B-450. The diameter of the runner is 5.5 m, the number of turns – 166.7 turns/sec, capacity – 51.5 MW.

For the purposes of repair and inspection, notches of repair locks (6.0-6.0-20.2) will be provided in the holes opening into the downstream area of water discharge pipes located in the area of the turbine through which the water will pass. The lock will be operated by means of a frame crane of 2 x 10 ton bearing capacity.

The water processed in the power plant flows into the downstream chamber. The chamber is separated from the river by means of a reference wall in order to avoid penetration of sediments during floods or when the reservoir is washed.

2.3.2. Namakhvani HPP

The Namakhvani HPP is the second step of the cascade that will use the river Rioni fall between 310.00 m and 232.00 m levels. The Namakhvani HPP is located near the Namakhvani village of Tskaltubo region, 3 km upstream on the Rioni River.

The main structures of the Namakhvani HPP include: concrete arch dam, construction tunnel, operational spillway, dam outlet (flood discharge), power plant building and discharge canal. All structures belong to the 1st class of capital construction standards. See [APPENDIX 13 – Drawings – Namakhvani HPP](#).

The concrete arch dam is based on rocky deposits – tuff-breccias. The normal water accumulation level is at 310.00 m. The total capacity of the reservoir is 156 million m³, useful capacity – 52 million m³, the area of the reservoir's water surface – 4.9 km². The arch dam sits on the basement penetrating into steady rock sediments, while in the river bed area – based on concrete plug.

The maximum height of the dam is 111 m, the height of the arch – 86 m and the height of the plug – 25 m. The width of the dam varies from 3.5 m at the crest of the dam, to 13.4 m at the plug. The crest of the dam is located at 311.00 m level. The length of the dam at the crest, excluding the pillars is 315 m, at the chord – 272 m. The ratio of the chord to the dam height is 3.2 and ratio of dam base thickness to its height is 0.156.

There will be a 15 m deep concrete reinforcement and 45 m deep two layers of anti-filtration curtain at the bottom of the dam. A drainage curtain with a 40 m deep well will be arranged below the anti-filtration curtain.

The arch dam will have two in-depth outlets. Their axis will be at 236.00 m level. The water will pass through these outlets when the water flow is low, the plug of the construction tunnel must be closed and water consumption needs to be regulated during the initial stage of filling the reservoir. Conductivity of each filament is 360 m³/sec. The diameter of the metal pipes of each outlet is 5.0 m. length – 77.0 m. The outlet starts in the body of the arch dam, while the rest of it passes through the downstream area - the concrete body located between the HPP building and the rocky slope of the left bank. The distance between the outlets is 7.3 m.

Main and repair locks will be arranged in the holes located in the downstream area. The locks are designed to bear the maximum pressure created by the dam because the outlets can be used during the uninterrupted operation of the power plant, in order to empty the reservoir. The locks are operated by means of a hydraulic drive, located at 250.0 m level.

697 m long construction tunnel will be built on the left bank of the river in order to divert the river water during the construction period. The threshold of the tunnel entrance portal will be at 234.35 m level. Its cross-section will be 12 x 12 m. The tunnel is designed for 1700 m³/sec flow rate (in case of 0.1% provision). The width of the concrete lining of the tunnel will vary from 0.4m to 1.0m. Flat, sliding 12.0 x 14.0 m locks will be used to close the construction tunnel. When it is time to close the tunnel the locks will be installed at the tunnel threshold by means of auto-crane.

Operational spillway will be arranged on the left bank of the river in order to pass maximum flow rate. The spillway will consist of an open header and inclined tunnel that will join the construction tunnel at 59° angle. The spillway is designed to pass 3325 m³/sec flow rate in case of 0.01% provision.

The route of the construction channel and the spillway will cross tuff-breccias and tuff-gravel deposits. The cross-section of the inclined section will be 12 x 12 m. The front line of the spillway of the horizontal header is 10.0 m long. The length of the transition section equals 16.0 m, while the length of the inclined section – 25.0 m. In order spill water, regulate the upstream water level and prevent penetration of floating objects, the operational spillway will have two locks with segment valves. The locks will be operated by means of hydraulic drives. A stationary hoist

(bearing capacity 2 x 100) will be used to carry out installation and repair of the segment locks. Flat sliding locks will be installed in front of the segment lock. It will be operated by means of overhead hoist, bearing capacity – 2 x 10 tons.

Two water intake towers are located on the arch dam, from the upstream side, where two turbine headraces start. They pass through the plug of the dam. Estimated flow rate of each headrace line 125 m³/sec. The height of the tower is 81.7 m. The water intake threshold is located at 288.0 m level. The size of the water intake hole is: height – 9m, width – 5m. Each water intake tower has six water intake hole equipped with grids to prevent penetration of wastes. The grid parameters are 5.0-9.0-2.0. They can be cleaned in raised position.

All grid and lock related operations will be carried out by means of an overhead hoist and a frame crane.

7m cylinder lock will be used during repair and emergencies. It will be operated by means of a stationary hoisting rope, bearing capacity - 150 tons. The existing aisles between the dam crest passage and the towers will be interconnected by means of one span metal bridge.

The open HPP building located near the dam will be in the downstream area, in the Rioni River bed, between 202.00 and 250.00 m levels. The size of the building is 20.0 x 60.5, the height – 48.0m. Inside the HPP building two units will be installed, 105 MW each. Estimated water consumption of the HPP is 366 m³/sec, estimated head – 64.9 m. Annual generation of electricity will equal 928.0 million kWh.

The distance between the unit's axes is 17m. Water will be supplied to the turbine by means of metal headrace, covered with concrete.

The turbine floor will be at 223.00 m level and the machine room – at 231.50 m level.

The roof of the intermediate floor will be rested on the generator shell and concrete walls of the HPP building. The machine room will be covered with a 25m wide reinforced concrete block. The machine room will be equipped with 20m beam bridge crane.

The size of assembly field will be 20.0 x 21.5m. It will be located to the right of Unit 2, at the machine room level of 231.50 m. The equipment will be delivered to the assembly field, inside the covered HPP building by means of the 5.0 x 5.0 m access. The equipment will be delivered to the assembly field, up to the HPP building by means of the automobile road.

The turbine to be installed at the Namakhvani HPP should have been the one developed by the Kharkov Turbine Factory. The turbine type is ДПЛ 90-B-450, with a bucket rotating in the vertical-diagonal directions.

During inspections and repairs the outlets of ventilation pipes in the downstream area will be closed by means of a flat lock – 5.75-6.10-21.70. The gates are operated by means of a frame crane with a spool catch.

A bridge crane will be installed in the machine room of the power plant, bearing capacity – 400/80 tons.

The water processed in the power plant is directed into the Rioni River by means of a discharge canal. The soil in the area where The HPP building and the initial section of the discharge canal will be located is tuff-breccias and tuff-gravel. The inclination of the canal sides will be 3:1. The bottom and sides of the canal will have concrete lining.

2.3.3. Zhoneti HPP

Zhoneti HPP is the last step of the cascade. It will use the river Rioni fall between the downstream level (232.00 m.) of the Namakhvani HPP and the Gumati 1 HPP reservoir level (200.00 m.). The Zhoneti HPP is located near the Zhoneti village, 7 km downstream from the Namakhvani HPP.

The hydro structures of the Zhoneti HPP include: embankment dam, surface water outlets and under-water spillway, power plant building, dissipation well, construction tunnel, operational spillway, dam outlet (flood discharge), and discharge diversion canal (to be used during construction). All structures belong to the 1st class of capital construction standards. See [APPENDIX 14 – Drawings – Zhoneti HPP](#).

The embankment dam is located at the river bank level, which is 205.30 m. Normal water accumulation level of the reservoir is 232.00 m. The total capacity of the reservoir is 12.5 million m³, useful capacity – 6.0 million m³, the area of the reservoir's water plane – 1.25 km², minimum - 8m, length – 174 m. The dam consists of vertical clay core, fragmented gravel filters and other supporting stone prisms. The inclination of the upper prism slope is 1:1.7 and 1:1.6, while the inclination of the lower prism slope - 1:1.6 and 1:2.0.

The upper prism of the dam will adjoin with a barrier penetrating into the dam body. The supporting prisms of the dam will be stone embankments. Useful material dug out during the construction will be used to arrange the embankments.

The upper slope will be fortified with a 2 meter layer of large stones.

The core of the dam will partially sit on the main rocks which are tuff gravel and tuff shale deposits, tuff-breccias layers of average width (above the river brink, on the left bank, after removal of sand-gravel) and partially on the gravel of the river bed.

On the right the embankment dam will adjoin with the HPP building.

A bypass canal will be arranged to divert water during the construction. The size and inclination ($i=0.01$) of the diversion canal were determined based on hydraulic calculations, estimated flow rate – 1700 m³/sec, which corresponds to 1% provision and allowed velocity - 10m/sec. The cross-section of the dam has a trapezium form. The bottom is 36.0 m wide. The inclination of the canal slope is 3:1; the canal length is 199.5 m.

The threshold of the water intake will be located at 190.00 m level.

The HPP building will be on the left bank of the Rioni River. The size of the HPP building will be: width – 54.9m, length – 63.50m, height – 60.05m. The machine room will be at 203.60 m level. Two units, 45 MW each, will be installed inside the HPP building. The turbine type will be ПЛ 30/800-B-500, with a rotating bucket. The estimated flow rate through the turbine will be 202.5 m³/sec, estimated head – 26.0m.

The size of assembly field will be 30 x 20m. It will be located to the left of Unit 2, at the machine room level of 203.60 m. The access to the assembly field will be by means of the automobile road. Installation inside the machine room will be carried out by means of the bridge crane, with 18.5 m beam and 2 x 112/32 ton bearing capacity.

The roof of the HPP building is a water outlet of a practical profile used to spill part of the flood water during the HPP operation. Its apex will be at 223.38 m level. The estimated discharge rate of the water outlet - 1570 m³/sec - was defined taking into consideration the maximum water flow – 3700m³/sec (0.01% provision). The length of the water discharge front is 45m and it is divided into three lines.

Main locks (15.00-8.00-8.62) will be located at the entrance of the surface outlet. They will be operated by means of a stationary hoist mechanism of 2 x 60 ton bearing capacity.

A bottom spillway will adjoin the units from the left bank side. Its throughput is 1730 m³/sec.

The threshold of the in-depth spillway will be at 195.10 m, the length – 54.90, the level of the bottom in the downstream area – 183.35m, the width of the entrance hole – 15.00m, the height – 6.2m. A middle support will divide the spillway into two lines. The in-depth spillways of the upstream area and downstream area will be equipped with flat locks.

Dissipation of energy will be carried out downstream by means of a 70m long and 18m wide dissipating well.

The discharge canal is designed to conduct 405 m³/sec estimated flow rate. Its length is 1972.6 m. The cross-section of the canal has a trapezium form. The inclination of the canal sides will be 3:1. The soil along the discharge canal rout is tuff-breccias and tuff-gravel covered with pebble-gravel deposits.

A side outlet will be arranged at the discharge canal, in the immediate vicinity of the dissipating well. The outlet will be designed for 3310 m³/sec throughput. The outlet threshold is at 202.00 m level. Its width is 121.0 m.

The mechanical part of the HPP is located in the upstream and downstream areas. In case of necessity the front paired holes at the entrance of each turbine chamber can be closed by means of emergency/repair locks 6.25-7.20-42.14, operated by means of hydraulic drive. Both holes located at the entrance of each turbine chamber are covered with grids that can be cleaned by means of clam-shells. In case of necessity repair locks can be installed in the notches of the grids. The three holes of the surface outlet can be closed by means of 1m high flat roller locks 15.00-8.80-8.62. They will be operated by means of 1m high stationary rope hoists. Repair locks (15.00-10.40 x 9.75) will have notches in front of the main lock notches.

The in-depth outlet is locked by means of flat roller locks 6.25 x 6.40 x 42.14. The locks are operated by a hydraulic hoist (650-250-100-6.7)² that is installed in a special niche above the notches of a pressurized cover.

The repair locks of the waste-screening grid, clam-shell, surface outlet and in-depth spillway will be operated by means of a frame crane of 2 x 175 and 2 x 20 ton bearing capacity.

For the purposes of repair and inspection, the ends of exhaust pipes can be closed by means of sliding locks 6.25-6.58-23.00, while the outlets of the in-depth spillway can be locked by means of section locks 6.25-8.60-10.89.

Operation of the wicket gates located in the downstream area will be carried out by means of a lifting mechanism – 2 x 10 ton bearing capacity.

2.4.ELECTRICAL PARTS

According to the decisions of the State Energy Commission and the State Planning Committee of the USSR, after the 1st stage of reviewing the project, the Namakhvani HPP cascade was going to deliver generated electricity to the energy network at 220 kV. It was planned to build one 220 kV overhead line coming from the Namakhvani HPP and two 220 kV overhead lines for each – Zhoneti and Tvishi HPPs. The connection point would be the substation of Kutaisi Automobile Factory and Lajanuri HPP.

The Zhoneti and Tvishi HPPs would have a “block system”. The integrated block system would be connected to the 220 kV switchyard having a triangular scheme – two 220 kV outcome lines.

The scheme of electric connections of the Namakhvani HPP will be of a block type - a generator-transformer will be connected to the 220 kV overhead line by means of the generator's circuit breaker and a line circuit breaker of the relevant voltage.

Self consumption will be provided by means of an auxiliary transformer fed from the network branch – before the generator's switch. Self consumption back-up is provided from Gumati 1, by means of 35 kV transmission line.

The location of equipment within the HPP building and its extensions was determined according to the electric connections of circuits.

Step-up transformer and high voltage open switchyard will be located near the HPP buildings. The open switchyard at Namakhvani HPP will be arranged on the roof of the power house building and its extensions.

At all the power plants connection between the generator and transformer will be made by means of factory closed screened power conductors.

The hydropower plants of the Namakhvani cascade would be dispatched by Central Dispatch and included into the regional power network. Besides, they had to be a component of the group of cascades on the Rioni River, where the Rioni HPP would serve as a base station.

The above mentioned power plants were designed using maximum possible level of automation and remote control with the base station and Central Dispatch.

The external connection of the Namakhvani Cascade was planned by means of underground cable and equipment TH-12-TK-E.

The main telecommunication facility is located in Kutaisi. A cable will be laid between the Rioni base HPP and Lajanuri HPP. Back-up of the connection will be provided by means of high frequency channels and 220 kV overhead lines. The last will also be used for security, remote control and accident-prevention automation.

Connection between the equipment located inside each power plant was designed in compliance with the standard requirements (telephone connection, loudspeakers, internal communication for system of the station, also the director's and security's communication systems).

2.5.CONSTRUCTION OF HOUSING

The plan envisaged construction of three settlements to provide housing for the construction/installation personnel and operation personnel:

1. The site of former settlement used during the construction of the Gumati HPP;
2. Near the village Mamatsminda;
3. In Kutaisi (two 8 story buildings)

The plan envisaged construction of buildings for economic, household, cultural, educational, communal, trade etc. purposes.

Description	<i>Settlement in Gumati village</i>	<i>Settlement in Mamatsminda village</i>	<i>Two 8-story Buildings in Kutaisi</i>
Area under construction (hectares)	18.5	13.0	-
Population number (people)	3 516	3 723	337
Living space (m ³)	40 918	30 715	19 900
Total common space (m ³)	61 818	55 207	19 900

2.6.SANITARY ENGINEERING

2.6.1. Water Supply System

The Nabakebi springs, located 7-12 km away from the settlements and the power plants, will be used to supply water to Mamatsminda settlement, Namakhvani HPP and Zhoneti HPP.

A spring North of Tvishi village, located 5 km away from the construction site, will be used to supply water to the Tvishi HPP.

The project envisaged creation of an integral water supply system.

Water dispersion equipment will be used to extinguish fire on generators installed within the Namakhvani HPP buildings. It is planned to install fire-cocks in the buildings.

According to the plan, circular water supply network with hydrants in 50 meter intervals would be arranged at the Namakhvani HPP Cascade sites.

2.6.2. Sewage System

The plan envisaged construction of the central sewage system facility with biological cleaning of the waste water for Mamatsminda settlement and power plant buildings.

2.6.3. Heat Supply and Ventilation

According to the plan the heating of power plant buildings would be carried out using calorifers (electric heating) and ventilation – by means of ventilators.

2.7.ROADS

Roads play critically important role in the construction of the Namakhvani HPP. They provide the only access to the sites where construction materials are located in Kutaisi and Tskaltubo. They also connect HPP facilities to those enterprises and settlements that are located on the territory of the construction site.

Roads are divided into three groups:

1. Roads that must be rerouted to avoid the reservoir zone;
2. Permanent roads;
3. Temporary roads;

Roads of republican and regional importance belong to the first group. Some sections of these roads will be flooded by the reservoirs under construction. In order to keep these roads operational, their rerouting to another place is required. Total length of the roads under the first category equals 60.3 km.

Permanent roads belong to the second group, which are expected to be used during the construction of HPP structures and after the construction is completed these roads will be for operational purposes of the plant structures. Total length of these roads amounts to 42.2 km.

Temporary roads, included into the third group, are expected to be used for the construction of auxiliary structures of HPP (temporary facilities, tunnel construction etc.). Total length of the temporary roads will equal 40.4 km.

2.8.ORGANIZATION OF HYDRO-ELECTRIC CONSTRUCTION

The construction sites are located in Tskaltubo and Tsageri regions, 17, 25 and 55 km from construction storage facilities in Kutaisi.

According to the plan the construction storage facility (located at the railway route), construction center and construction facility near Vartsikhe HPP will be used during the preparatory stage and construction stage. The plan provides for usage of Gumbrini facility too, which is located in Tskaltubo region.

The transportation scheme envisages transportation of construction materials and equipment by railway to the storage facilities in Kutaisi and Gumbrini and further transportation to the construction sites by means of automobile transport.

The total number of employees needed for construction and transportation is 2785 people. During the preparatory stage temporary accommodations for 827 people will be needed.

The storage facility located near the railroad in Gumbrini will be used as a central one i.e. it will include: car park for 150 construction cars, car park for 150 transportation cars, maintenance facilities for cars and transport etc. The power supply will be provided from a temporary 110/35/6 kV substation arranged at the construction site of the Zhoneti HPP and 35/6 kV substation arranged at the construction site of the Namakhvani and Tvishi HPPs, also, a 6/0.4 kV transformer substations arranged at the construction site of Namakhvani, Zhoneti and Tvishi HPPs, with the corresponding 6 kV overhead transmission lines.

A concrete factory will be arranged on the territory of the hydro-electric scheme, near the Sakire and Tvishi villages. The capacity of the factories will be enough to cover the construction needs during the peak year.

Other facilities to be located on the territory include: an asphalt factory, various facilities, facilities of specialized organizations, garage, and warehouse for explosive materials etc.

1473 thousand m³ of concrete will be needed, out of which 624.5 thousand m³ will be required for the construction of roads, bridges and automobile tunnels. Open pits for sand and gravel are located in the Rioni River bed, in the villages Zhoneti, Molekura and Oncheishi. The sand deposit of the r. Kvirila will be used to produce concrete needed for the arch dam.

The clay deposit located near the Mamatsminda village will be used to build the kernel of the embankment dam of the Zhoneti HPP.

According to the project schedule the construction duration will be 7 years and 3 months.

3. ENVIRONMENTAL AND SOCIAL ISSUES

Materials of qualified sub-contractors were used for developing this chapter. With the aim to draw up materials TbilHydroProject invited up to 40 design and scientific-research institutes under the Georgian Academy of Sciences.

3.1.NEEDED MEASURES IN ORDER TO PREPARE AREA FOR THE RESERVOIRS.

3.1.1. Economic Characteristics of the Region.

The basic sector of the rural economy is agriculture – viticulture and horticulture. Field husbandry is of secondary importance and the mountain pastures are used for cattle breeding.

At the end of Namakhvani reservoir, in the nearby villages Tvishi and Orkhi, high-quality viticulture and wine-making micro-region was created, which produces highly valued “Tvishi” wine. Vineyards located below this area yield lower quality wines. Following fruit species are grown here: apple, pear, plum, peach, fig, walnut etc. There are also small tea plantations.

Industry is represented by small enterprises processing agricultural products. There is a winery in the village “Tvishi” and heavy spar deposit which is not currently operated. Proposed construction area is relatively densely settled.

Main transport passageway is Kutaisi-Alpana-Mamisoni Mountain Pass road, routed along the right bank of the river Rioni.

3.1.2. Agricultural Production Losses and Their Compensation.

The total area of land allocated for the construction is 1743.13 hectares. The area under the reservoirs and river banks is 924.71 hectares, including 296.94 hectares of agricultural land – out of which 27.06 hectares of hayfields, 152.50 hectares of pastures, 32.90 hectares of gardens, 29.93 hectares of vineyards, 51.60 hectares of private farms and 2.95 hectares of tea plantations.

In order to preserve the area of available agricultural lands, the project provides for compensation per hectare. Funds for reimbursement of lost agricultural lands are included in the total cost estimates of the construction. Alienation of land for the construction purposes of the cascade will not considerably affect agricultural production capacity of the region. Area of land to be alienated (used for construction) in Tskaltubo district amounts to 1.81% of total land fund of that district, in Tsageri district it amounts to 0.51% and in Tkibuli district only 0.08%. Cost determined for reimbursement of lost agricultural land was defined by resolution of the Council of Ministers of Georgia issued in 1976.

3.1.3. Resettlement of Population and Associated Loss Reimbursement by the Project.

Construction of the Namakhvani HPP Cascade (according to Inventory Bureau of Tskaltubo district) will affect 202 farm land plots in Tskaltubo and Tsageri districts with 436 persons. Only 45 private farm land plots are located within the Tvishi HPP reservoir zone. 109 private farm lands are located within the Namakhvani HPP reservoir zone (Tskaltubo district) with population of 309 people. 30 private farm lands are located within the Zhoneti HPP reservoir zone, with population equal to 75 persons. See [APPENDIX 16 – Documents on Provision of Land for Resettlement of Population](#).

Settlements affected by the construction are not well developed. Sources of water supplies are small springs and wells. The sewage system does not exist. The territory is supplied with power. Typical houses are two-floor dwelling houses, the first floor is usually built with stones and the second floor is made of wood with balconies. Facilities in the yard consist of kitchen under the light construction roof, premises for animals, hen house, storages for corn, baking well, wine-cellar. Farm land is surrounded with a fence. Besides private houses there are buildings in the reservoir zone used for public and state purposes. According to the project 99 private farm land plots with 279 people, which are currently located in the area to be covered by the reservoir, should be moved to an area allocated on the territory of village Derchi:

- 10 private farm land plots with 32 people from village Molekura;
- 10 private farm land plots with 20 people from village Derchi;
- 38 private farm land plots with 110 people from village Kveda Oncheishi;
- 8 private farm land plots with 20 people from village Zeda Oncheishi;
- 33 private farm land plots with 97 people from village Mekvena.

Population will be provided with dwelling, household facilities and farm land with total area of 0.25 hectares. Compensation costs for resettled population are included in the project budget.

3.1.4. Rerouting of Roads

As was described above, highway Kutaisi-Alpana-Mamisoni Mountain Pass road represents main thruway, which connects Kutaisi and Tskaltubo with the settlement located on the right bank of the river Rioni and mountain regions.

The reservoirs will flood:

- Abovementioned main road located on the right bank of the river;
- Ferryboat passage and respective access roads;
- Roads connecting villages Derchi, Chortisa and etc to the main road;
- Motor-car and foot bridges and respective access roads.

The project envisions construction of new roads for re-routing the abovementioned roads.

3.1.5. Redesign of Power and Communication Facilities.

High voltage transmission line “Gumati HPP – Lajanuri HPP” is built at the construction territory of the Namakhvani HPP which is connected to three substations supplying power to the adjacent territory. The abovementioned high voltage transmission lines are constructed in 1950-ies, mostly using wooden supports which need to be replaced completely. Communication lines and poles are also very old and need to be replaced. Funds for these replacements are included in the project budget.

3.1.6. Woodstock Removal

There is lack of wood reserves in the construction district, because forest was intensively cut since ancient times. Deciduous forests prevail which can hardly satisfy the local demand for fire wood.

In the area of reservoirs trees and bushes must be cut. The cutting will be carried out during 4 years, until the reservoir is fully filled. The project for cutting and removing the wood was developed by Georgian State Land Design Institute “SakSakhMitsProekti”.

3.1.7. Sanitary Measures

The project for sanitary preparation of the reservoir area was developed by the Institute of Sanitation and Hygiene of Georgia.

The preparatory sanitary measures include:

- Cleaning of the territory from construction waste after demolition of houses;
- Removal of wastes from cesspools (sinkholes);
- Processing of cesspools with chloride-calcimine (chloride-lime) solution and filling back with ground;
- Relocation of graves and processing with chloride-lime solution;
- Filling of former graves with ground.

3.1.8. Fishing Facilities

The Namakhvani HPP construction can not cause any additional damage to fish movement because there are already the Vartsikhe, Rioni and Gumati hydro power plants downstream on the same river. The construction area is not important from the point of view of fish industry. After formation of the reservoir hydro-biological regime and food composition will change, which means that the fish species will change too. See [APPENDIX 17a – Letter from the Institute of Zoology on Fish Species and Fishing Industry](#).

The Engineering Institute “SakShavZgvaTevzMsheni” calculated the value of the total damage suffered by the fish industry, which is 3.85 tons. Therefore the Project includes measures to promote and expand breeding of the fish (namely - White Sturgeon).

3.1.9. Preservation of Precious Vineyards Producing High Quality “Tvishi” Type Wines.

One of the most important reasons for changing the project from a two-step cascade to a three-step one was to avoid flooding of vineries with “Tsolikauri” species of vines in the Tvishi and Orkhevi villages, where the unique soil and climate produce the high quality “Tvishi” wine. The research carried out by the Scientific Research Institute of Viticulture and Horticulture of Georgia demonstrated that relocation of the vineyards to other zones and levels would change the wine

quality. See [APPENDIX 17b – Letters from the Institute of Viticulture and Horticulture on Tvishi Vineyards](#).

3.2.CHANGES IN ENVIRONMENT CAUSED BY THE HYDRO POWER FACILITIES AND MEASURES TO MITIGATE THEM

3.2.1. Landscape Changes due to the Construction

The Landscape Laboratory of the Institute of Geography carried out research to assess the possible impact of the construction on the landscape. The study revealed that the natural conditions were convenient for the construction. As for the landscape and environment surrounding the Namakhvani cascade reservoirs, its natural and anthropogenic factors are complicated and the situation might be near crisis if the work is not performed properly. The landscape will not suffer in case of prudent construction and operation of the cascade.

3.2.2. Impact of the Reservoirs on Hygienic Condition of the Area

In 1983-1991 the Institute of Sanitation and Hygiene of Georgia studied the possible impact of the reservoirs on the hygienic condition of the territory (from Alpana to Zhoneti). The study demonstrated that the sanitary-hygienic situation had not deteriorated during these years and in some cases even improved. The water quality is not deteriorated or improved by Namakhvani Cascade reservoirs. See [APPENDIX 17c – Letters from Chief Sanitary Doctor of Georgia and Council of Trade Union's Resorts Management on Water Quality](#).

Following measures are recommended to improve the water quality:

- Creation of complete sewage systems and cleaning facilities for large settlements in the region;
- Industrial enterprises must have local cleaning facilities for cleaning contaminated water;
- Use of fertilizers must be limited on the territory adjacent to the reservoirs;
- Big cattle breeding farms must be equipped with facilities for biomass processing.

3.2.3. Impact of the Reservoirs on Malaria Situation

In order to forecast possible impacts of the reservoir, the Institute of Parasitology and Tropical Diseases carried out research of all analohpenogenic pools within 5 km radius. The construction area is characterized by complicated long term epidemiological factors, with a long season that enhances potential development of malaria. At the same time it must be noted that since 1970 there have been no registered cases of malaria in Georgia.

The analysis of malaria enhancing factors in this epidemiological zone showed that increase of malaria incidence caused by the construction can not be discarded. Preventive measures will be necessary, such as:

- Stronger epidemiological health monitoring;
- Medical inspection of workers and employees and their families.

3.2.4. Impact of the Reservoirs on Radiological Situation

The impact of the reservoirs on the Rioni River basin from the radiological point of view was studied by the Institute of Agriculture Radiology. The radiation level in the basin of Rioni River is 7-15 $\mu\text{rad/hr}$, which does not accede the average background radiation level in Georgia. In gamma spectrum analysis only cesium radioactive nuclide is detected in all studied samples. Composition of other radioactive nuclides was lower than the spectrometer sensitivity and did not exceed the natural level.

The Namakhvani HPP construction will not contaminate the Rioni River water.

3.2.5. Impact of the Reservoirs on Health of Local Population

The Institute of Sanitation carried out research to estimate the impact of reservoirs on the local population's health. I was based on an analogy of the similar research conducted for Gumati

HPP reservoir. Health inspection of a group of people living in similar conditions was carried out. Health inspection of the population of 10 villages took place (Ophurchkheti, Gumati, Namakhvani, Zhoneti, Zarati, Sormoni, Mamatsminda, Jimashtaro) using achieve materials for 1973 - 1980 and 1987 – 1989. The death and birth rate data is also available. The health history of all registered patients and the history of medical services received by them were also investigated.

The analysis showed that the most frequent health problems are those of the cardio-vascular system, digestion system and respiratory system. There have been no special deviations in the health or climate conditions that might be caused by the Gumati reservoir.

Based on the research results the population's health is assessed as average.

3.2.6. Impact of the Reservoirs on Vegetation

The Institute of Botany, the Institute of Vegetation Protection and the Institute of Forestry carried out independent studies of the vegetation at the construction site.

According to the conclusion made by the Institute of Botany, the construction and further operation of the power plants will not have any serious negative impact on the vegetation.

The Institute of Forestry studied the impact of Lajanuri HPP reservoir on the similar forest in order to forecast the possible results of Namakhvani cascade. Based on the research results the Institute made a conclusion that physical parameters of water, surface and soil water flow will not change significantly, therefore the reservoirs will not make a negative impact on the forest eco-systems.

The Institute of Vegetation Protection made a research into the bio-ecological vermin systems. The research demonstrated that the average ambient temperature and humidity play an important role. Since the air temperature and humidity will not change, the reservoirs will not impact the biological characteristics, growth and development of vermin.

3.2.7. Impact of the Reservoirs on Fauna

The Institute of Zoology carried out a research of the fauna within the Gumati HPP area in order to assess possible impacts of the wildlife.

- No significant change of the qualitative and quantitative characteristics of the surface fauna is expected. Migration of only some of the mammals will take place;
- Zoological productivity of the reservoir will be very low;
- As Gumati and Vartsikhe HPP reservoirs are already built downstream, Namakhvani Cascade reservoirs can not affect the fish movement of the Rioni basin.

3.2.8. Impact of the Reservoirs on Climate

In order to assess the possible impact of the Namakhvani cascade reservoirs on the local climate the Scientific Research Institute of Hydrometeorology used the data of Gumati and Lajanuri reservoirs because of their proximity and similar natural conditions. Similarly, data of Gali and Tbilisi reservoirs were used to forecast water temperature.

The results demonstrated that no climatic changes are expected in Rioni River basin due to construction of the reservoirs.

3.2.9. Impact on Historical, Cultural and Natural Monuments

The middle section of the Rioni River passes through the central part of Georgia which is very interesting from the historical point of view. The Institute of History, Archeology and Ethnography organized an archeological expedition in order to study the area and its historical monuments. The expedition identified 27 monuments that need to be studied. The cost of such work is included into the total cost estimate of the construction. Also see [APPENDIX 17d](#) –

3.2.10. Recreational Development of the Area

The beautiful landscape and existence of the tourist routes create beneficial conditions for the development of the tourism and recreation zone. The whole complex of recreation and tourist facilities can be created in the vicinity of the reservoirs.

3.3. PROTECTION MEASURES OF THE SEA BEACHES NEAR POTI

The Kolkheti lowland was formed in the Holocene from sediments carried by the West Georgian rivers, mainly the Rioni River. The estuary of Rioni is near the town Poti. There are two flows getting into the Black Sea forming an island called “Bolshoi”, on which part of Poti is located. After Rioni River flow was diverted into the river Nabada, the afflux of sediments at the old estuary stopped and acute deficit of hard deposits was created. As a result sea beaches near the former delta are intensively washed-off.

Construction of the Namakhvani cascade will reduce the afflux of hard deposits to 1 million m³. At the same time it must be noted that the hydrography of the river will be improved thus increasing sediment transportation ability of to the river link flowing in the city area. Based on the above, we can forecast that construction of the Namakhvani cascade will create annual 300- 400 thousand m³ deficit of hard deposits in case of 320 m³/sec water flow of the Rioni River link in Poti area.

Taking into consideration the above circumstances the project includes certain measures for protection of the Black Sea beaches near Poti. See [APPENDIX 17e – Letter from “SakZgisNapirDatsva” on Protection Measures for Poti Sea Beaches](#); [Letter from State Committee of Environmental Protection on Protection Measures of Poti Sea Beaches](#).

Several possible options were reviewed. The most effective measure is to relocate the “Bolshoi” shoreline 320 m into the sea and raise the beach level by 1.5 m, which exceeds the estimated multi-year sea level. According to the technical specifications, the volume of earth needed for the embankment is 3.98 mln.m³ and construction period – 3 years. Later, 200 thousand m³ will be needed annually for restoration of the washed-off areas.

4. PROJECT COST ESTIMATE

The cost estimate of Namakhvani Cascade construction was based on 1984 year prices and the approved amount equaled 386.822 million Rubles ([APPENDIX 10 – Project Documentation, Part IX, SubPart 1, Vol 1 – Budget Documentation – Summary](#)).

Description of Expense	Industrial Facilities	Housing & Civil Facilities	Pioneer Camp for 240 Children	Total Cost (Thousand Rubles)
Construction and Installation	221 180.40	35 792.72	656.03	257 629.15
Equipment, Furniture and Inventory	47 999.40	3 569.04	79.93	51 648.37
Other Expenses	74 113.80	3 329.26	101.67	77 544.73
Totals:	343 293.60	42 691.02	837.63	386 822.25

As was mentioned above, total cost of construction of Namakhvani HPP Cascade was estimated at 386.822 million Rubles. This amount, based on official exchange rate (1.00 Ruble = \$0.68 USD) at the time of its approval, was equivalent of \$567.756 million USD.

In 1993 rough recalculation of the total cost estimate was made, which resulted in the total cost of construction \$533.920 million USD. Out of this cost of Tvishi HPP amounted to \$141.951 million USD, cost of Namakhvani HPP amounted to \$259.346 million USD and cost of Zhoneti

HPP – \$133.480 million USD. Within these prices cost of equipment was estimated at \$300 USD per 1 kW.

Verification of construction costs according to current market prices and legislation requires thorough review of number of technical and organizational issues. This effort would be time-consuming and requires financing, including execution of certain design works and re-negotiations with local government bodies and other stakeholders.

At this stage, in order to determine current project cost, recalculated budget produced back in 1993 is taken as a basis. Construction and installation costs under that budget are more or less close to the current market rates. Old prices of the equipment are subtracted from that total and current equipment prices are added at an average international market price of \$500 USD per kW. Taking the above into consideration, the new cost of equipment would be: Tvishi HPP – \$50 million USD, Namakhvani HPP – \$125 million USD and Zhoneti HPP – \$50 million USD. Thus the construction costs for these three HPPs are determined as follows:

- Tvishi HPP – \$161.951 million USD
- Namakhvani HPP – \$309.346 million USD
- Zhoneti HPP – \$153.480 million USD

Total cost of the construction of Namakhvani HPP Cascade would be \$624.777 million USD.

5. CURRENT CONDITIONS AND NEEDED CHANGES TO THE FUTURE PROJECT

Construction works performed during the first phase of construction in 1988-89 years included the following:

1. The existing automobile road (D-11) from village Gumati till village Zhoneti was reconstructed;
2. The road bypassing Kutaisi, was leveled from Kutaisi till Gumati village (D-12);
3. A terrace was arranged near Sakire village for the concrete factory; a road was built leading down from the existing road; The terrace was planned and the existing water streams diverted to Rioni River by means of square reinforced concrete pipes;
4. Set up of the research & development base was started in Tskaltubo. Construction of the main building was completed;
5. An access road D-6 was built leading from existing road near the Tvishi village to the automobile tunnel entrance. Using this road the tunnel entrance portal excavation was started.
6. Construction of the access road from the road D-6 leading to the concrete crest of the dam on the right river bank was completed;
7. Construction of the access road leading to the construction site of Tvishi HPP was completed; warehouse for the materials was built on the site; temporary power supply source was set-up;
8. Road construction base was set-up for construction of roads D-11 and D-12;
9. Construction of the access road D-30 was completed near Tvishi village, which was leading from a bridge across Rioni River to the entrance portal of the bypass tunnel.

Since the time of Namakhvani HPP Cascade construction project suspension, the situation in the region has significantly changed. The population privatized and used some territories allocated for the construction:

- The warehouse facility located next to the railway in Kutaisi was divided into small enterprises and privatized. It can no longer be used for the construction.

- Private houses were built on the land plot allocated for a warehouse next to the railway in Gumboil village.
- The quarry territory to be used for the kernel of the Zhoneti HPP embankment dam was purchased by the local population. The territory to be used for temporary accommodation of workers was privatized too.
- The land located in the Tvishi village and allocated for the arrangement of the construction facility and workers' accommodation has also been privatized and used for construction of private houses.

Due to the above circumstances the Project has to be revised according to the actual situation and modern requirements. Below are suggested several modifications to the future project:

1. Dwellings of 25 families were falling under Zhoneti HPP reservoir flooded zone. They had to be resettled to a territory located at a higher level in the same village. It is necessary to review the possibility of lowering the reservoir level by 2-3 meters in which case the dwellings of the 25 families can be left unchanged. Energy parameters of the power plant must be assessed for this scenario.
2. Since the clay delft in Mamatsminda village no longer exists, it will be expedient to revise the Zhoneti HPP project and change the embankment dam with a concrete one. The other two power plants will have concrete dams and the concrete facilities and infrastructure have to be arranged anyway.
3. New political directions and market economy principles require revisiting several previous technical and organizational decisions in the project with corresponding changes in the budget documentation. Not only current construction material and equipment prices should be used, but certain objects should be partially or completely removed from the project. For illustration purposes some major ones are listed below:

Suggested Objects to be Removed from the Future Project	Cost Estimate in 1984 Prices (Thousand Rubles)
○ Pioneer Camp	— 837.63
○ Gas Pipeline on the quarry of river Kvirila	— 598.00
○ Gumati Construction Settlement	— 18 290.36
○ Kutaisi Housing (2x8 story buildings) *	— 0.00
○ Railway Storage Warehouse in village Gumbrini	— 3 865.60
Total in Thousand Rubles (1984 prices):	— 23 591.59

* Kutaisi Housing Buildings were to be financed from the city budget and were not included in the project cost estimate.

Following design and research work has to be redone for the future Namakhvani Cascade construction:

1. Re-inventory of the settled territories and land plots that will fall under flooded area or construction territory;
2. Inventory and engineering re-design of the road bypassing Kutaisi;
3. Revision and reassessment of the volume of civil facilities and housing;
4. Agreements & approvals from local governments should be re-negotiated and achieved;
5. The project for re-routing mountain crossing section of Kutaisi-Alpana-Mamisoni automobile road (D-1) was designed for 160 m arch dam scenario, and naturally it was passing on high elevation. No changes have been made to its design for a scenario where the dam is 50 m lower (approved project). A new project for the road (D-1) has to be developed in compliance with the current situation, using the existing road at the Derchi village;
6. New total cost estimate needs to be developed after making these revisions to the project.

6. ECONOMIC ASSESMENT OF THE PROJECT

6.1. Underlying Assumptions

Initial Assumptions: Major research works needed for Namakhvani HPP Cascade construction are already completed and certain materials exist. We have not attempted to assess the analysis contained in them. Design works have been completed and therefore the time and cost for preparation for construction continuation may be significantly lower than if a new concept were proposed. Qualified personnel needed for design, construction and further maintenance may exist. For example, Georgian specialists were employed in construction and rehabilitation works of 1300 MW Enguri HPP, 24MW Khadori HPP built in eastern Georgia by a Chinese state power company, in Baku-Tbilisi-Ceyhan oil pipeline project, oil-terminals and related linked infrastructure.

Estimated Project Completion Costs: Project cost by TbilHydroProject's rough estimation was approximately \$624.777 million USD, but taking into account that some items priced at \$20-30 million USD (opinion of specialists of the same Institute) should be removed from the future project, \$600 million USD can be taken as a basis for our calculations in this chapter.

Current Tariffs: The current tariffs on electricity generated by Georgia's large power plants are set by the Georgian National Energy Regulatory Commission and as of June 1, 2006 average 4.45 tetri/kWh (approximately 2.47 US cents). The Enguri HPP (the largest power plant in Georgia) tariff is 2.13 tetri/kWh (approximately 1.18 US cents), which certainly for newly built power plant would be unacceptable. However, it should be noted that for newly constructed Khadori HPP (in eastern Georgia) the tariff set by Georgian National Energy Regulatory Commission (as of June 1, 2006) was 7.16 tetri/kWh (approximately 3.98 cents). After rehabilitation of Vartsikhe HPP (Rehabilitation cost was 63 million German marks) under agreement also 3.5 cents were foreseen and the export of significant amount of electricity in Turkey was considered (The import price of peak energy in Turkey is believed to be at least about 4 cents).

Additional Export Market Information: Following a Turkish initiative, the development of a plan for a 500 kV transmission line "South Georgia" was forecasted in the late 1990's at 2.5 billion kWh power supply from Georgia and Azerbaijan into Turkey during 2000-2005, and from 2005 increased export to 5 billion kWh. Georgia's share in that earlier study was about 1.5-2 billion kWh. In recent years, the United Energy System of Russia several times expressed its wish to participate in the construction of this transmission line with the purpose to export electricity to Turkey. At the request of Georgian Government United States Trade and Development Organization is currently funding a full scale feasibility study for that line.

The potential demand for energy and power from Iraq or other regional countries is also believed possible but was not estimated.

6.2. Current and Anticipated Wholesale Electricity Market Structure

Present Wholesale Power Market In Georgia: The present structure of the wholesale electricity market of Georgia is a partially centralized market, in which all transactions are made through a single market operator, the GWEM. While originally structured only to manage transactions by others, instead, the GWEM has become much more like the supplier to the market. As there are certain "direct sales" made by generation companies or importers to larger industrial companies or to distributors, the market is not a true "sole supplier" market. None the less in many ways it acts like one. Major supply contracts are made to the GWEM, not to direct buyers. The generation prices which comprise the average price are based on tariffs, which in turn are set by the sector regulator, the GNERC. Actual prices charged by the GWEM however are not the hourly or even monthly transaction clearing prices normal to such markets. Instead, the GWEM price is set by rule as an annual average price, of 4.45 tetri (approximately 2.47 US cents) per kWh. Due to market rules, this price is effectively charged even to the direct contract buyers. Thus, despite some diversity in the market transactions, no price competition is allowed to exist.

Ministry of Energy Proposed Market Structure: To correct these conditions, the Ministry of Energy of Georgia has proposed that the market should operate as it was designed, with the GWEM as the market operator of a bi-lateral transactions based market. In such market, the distribution companies and other wholesale customers transact directly with generators, importers, exporters or other suppliers. Therefore, the Ministry has proposed to create three forms of sub-markets, with somewhat different pricing rules.

- Non-competitive plants are any thermal plants, any imports, and any new construction hydros for their first seven years. The non-competitive plants will be free to contract with any party at any price up to a price cap set by the GNERC. Each market buyer will be required to take annually a minimum percentage of non-competitive power, which percentage also to be set by GNERC. Namakhvani HPP Cascade plants would therefore be classified as a “non-competitive”. As estimated below, this could result in a somewhat higher price cap for operation of the Namakhvani Cascade with present pricing;
- Controlling plants are any hydro units large enough to control the market; at present this essentially means the Enguri hydro facility. The price for controlling plants will be set at the market average for all other plants; and
- Competitive plants, which effectively means all other existing hydro capacity. These will be able to compete at any price up to a price cap set by the GNERC.

The new structure of the Market which should be based on the abovementioned principles is expected to be approved and start its operations in the fall 2006.

Analysis of the Proposed Market Structure: To compare the impact of these and other pricing and market structures, CORE has created a simulation model of the operation of the Georgian power market. The base case of that model computes pure hourly least price dispatch of the all of the generation units, and import capacities to Georgia, and summarizes the results for 12 months. The base case model is based on estimated monthly plant availabilities, estimated unit output prices, and uses actual Georgian power system typical daily load patterns as well as customary dispatch pattern of the power plants for each month.¹ For purposes of this analysis, we set as the unit prices, the tariffs set by the GNERC for each plant. We then computed three different base scenarios, which are subsequently compared to cases with Namakhvani Cascade.

- First, we looked at what the total costs would be if the rates paid to each generation unit (or import) were based on the tariff rates. We have summarized the annual total revenues thus generated to each plant classification at the tariff rates;
- Second, we estimated generation unit revenues using hourly marginal prices (based on present tariffs), and summarized that data into annual total revenues by unit and sub-market classification
- Finally, we estimated price caps for the major sub-markets, competitive and noncompetitive power. We then looked at the “sub-market marginal price” for each classification, defined as, the unit price of the highest cost unit of that type, dispatched in each hour. That is, we estimate the price cap method to be used for simulated sub-market marginal price. We then computed unit revenues as if priced at their relevant sub-market marginal prices.

Results of Base Case Analysis: The results of this analysis are summarized on an annual basis in Table 1 below:

¹ For instance: in our simulation we used forced dispatch (instead of least price) of some thermal power plants located south-east from Tbilisi (those units were treated by the model as Must-Run units), resembling winter dispatch pattern of Georgian Power System caused by increased load in eastern part of Georgia and need for eastern grid stability. This forces several power plants to be dispatched by the model even though their output is more expensive than that of import power from neighboring Russia or Armenia.

COMPARISON of BASE CASE vs. BASE CASE + NAMAKHVANI CASCADE	A: Current Plants with Current Availabilities + Namakhvani with 90% of Run-of-River Plants' Availabilities					B: Base Case: Current Plants with Current Availabilities					Change Due to Scenario Compared to Base Case				
	Non					Non					Non				
	Total	Controlling	Competitive	Competitive	Competitive	Total	Controlling	Competitive	Competitive	Competitive	Total	Controlling	Competitive	Competitive	Competitive
Total Power System MWH:	7,993,608	2,293,410	2,714,927	2,985,271	37%	7,993,608	2,273,892	2,694,415	3,025,302	38%	-	19,518	20,512	(40,030)	
Market share:	100%	29%	34%	37%		100%	28%	34%							
Annual Revenues Based on:															
Tariffs	304,941,402	48,849,627	51,380,199	204,711,576		308,074,636	48,433,895	50,983,957	209,656,783		Lati.	Lati.	Lati.	Lati.	
Pure Marginal Cost	544,417,777	131,151,557	179,689,506	233,566,715		547,289,195	130,792,666	179,361,934	237,134,595		(3,133,234)	415,732	396,241	(3,945,207)	
Sub-Market Marginal Cost	398,301,261	48,849,627	115,884,919	233,566,715		400,427,786	48,433,895	114,859,296	237,134,595		(2,871,418)	358,891	337,571	(3,557,881)	
Average Revenue Per MWH:											(2,126,526)	415,732	1,025,623	(3,557,881)	
Tariffs	38.15	21.30	18.93	68.57		38.54	21.30	18.92	68.97		(0.39)	0.00	0.00	(0.40)	
Pure Marginal Cost	68.11	57.19	66.19	78.24		68.47	57.52	66.57	78.38		(0.36)	(0.33)	(0.38)	(0.14)	
Sub-Market Marginal Cost	49.83	21.30	42.68	78.24		50.09	21.30	42.63	78.38		(0.27)	0.00	0.06	(0.14)	
Increment in Revenues Over Tariffs															
From Pure Marginal Cost	239,476,376	82,301,930	128,319,307	28,855,138		239,214,559	82,358,771	128,377,977	28,477,812		261,816	(56,840)	(58,670)	377,326	
From Sub-Market MC	93,359,859	0	64,504,720	28,855,138		92,363,151	0	63,875,339	28,477,812		1,006,708	0	629,382	377,326	
Percent Change in Average Revenue:															
Due To Pure Marginal Cost	79%	168%	250%	14%		78%	170%	252%	14%		1%	-2%	-2%	0%	
Due To Sub-Market MC	31%	0%	126%	14%		30%	0%	125%	14%		1%	0%	0%	0%	
Impact on Total Annual MWH Capability:															
Dispatched MWH	6,040,077	1,682,171	271,360	1,356,010		4,968,306	1,669,292	1,356,010	1,071,770		Hydro:	Thermal:	Import:		
Total Available: MWH	7,748,250	5,825,400	12,964,800	12,964,800		5,910,403	5,825,400	12,964,800	12,964,800		1,837,847	-	-	(1,084,650)	
Net Available MWH (for Export)	1,708,174	4,143,229	12,693,440	11,608,790		942,096	4,156,108	11,608,790	766,077		766,077	(12,880)	1,084,650		

Table 1 – Comparison of Base Case vs. Base Case + Namakhvani Cascade

Both the pure market (pure marginal cost) and the sub-market price cap marginal cost models have higher revenues than the tariff model. Increased revenues are one intended effect of the change to proper market operations. The results of the base case condition are:

- The marginal cost pricing method estimates the total revenues that would occur from a pure market. This would increase the average annual cost to of 68.47 Lari/MWH (or 6.8 tetri/kWh). This would increase total revenues to generators by about 78%.
- The sub-market marginal costs using price caps, estimate the maximum impacts if that method is used to set the price cap. If all generator prices went only to the price caps, the effect would be to increase wholesale prices on average by 30% to 50.09 Lari/MWH (or 5.0 tetri/kWh).

Both, current and anticipated Wholesale Electricity Market structure allows sale of generated power as on internal so on regional (external) market. The new market would even encourage “direct sales/transactions” by the power plants to local or foreign buyer. As it is expected that power produced at Namakhvani HPP Cascade may be exported to southern countries, both market rules allow this. Current Base Case scenario shows over 5,000 GWh available for export (thus possibility of additional revenues for the Generators) by domestic Georgian generation.

6.3.Namakhvani HPP Cascade Case Comparisons

First, we estimated that the monthly availabilities of the Namakhvani Cascade will be almost the same as those currently applied for large Run-of-River hydro power plants.

We summarize the overall economic analysis of the Khudoni HPP, in the table below. The assumptions of this analysis are listed on the top of Table 2. All monetary values in Table 2 are in \$US. The assumptions summarized at the upper left of the table are largely self-explanatory, except that the per MWH operation costs, apart from cost of capital, are simply estimated as \$2.00/MWH. This value is approximate to the hydro power tariff set in Ukraine and which covers only operational costs for diverse units, including some quite large ones. The total capital cost of \$600 million is justified above. The other numbers are simply convenient estimates.

Four revenue estimates for Namakhvani Cascade are given in the table. Three of these are from the three forms of pricing directly generated by the dispatch model: present tariffs, pure marginal cost, and sub-market marginal cost. Note that since for purposes of sub-market classification (within the Ministry’s proposed partially deregulated market model), the newly built Cascade would be a “non-competitive” plant, the pure marginal cost and sub-market marginal cost rates and total revenues for Namakhvani Cascade are the same.

The fundamental economic conclusion of this analysis thus emerges quickly from examining the bottom of the table, “H – Expected Economic Rents or Revenue Deficits”. None of the three pricing models from the domestic Georgian market produces sufficient revenues to cover the estimated annual economic costs of operation of Khudoni HPP. Therefore, for convenience Table 2 also estimates the revenue value if the excess Namakhvani Cascade output were sold for export. Note that only by doing so is the full economic cost of the Namakhvani Cascade covered. (Alternatively, the internal Georgian market price might be allowed to rise to the export price; that scenario was not evaluated for this study). The result of adding revenues from exporting excess (undispatched internally for Georgian domestic load) power output is shown at the very bottom of Table 2 in “J – Adjusted Expected Economic Rents or Revenue Deficits after Including Export Sales”. This latter case allows meeting the costs and recovering investments in the shortest time.

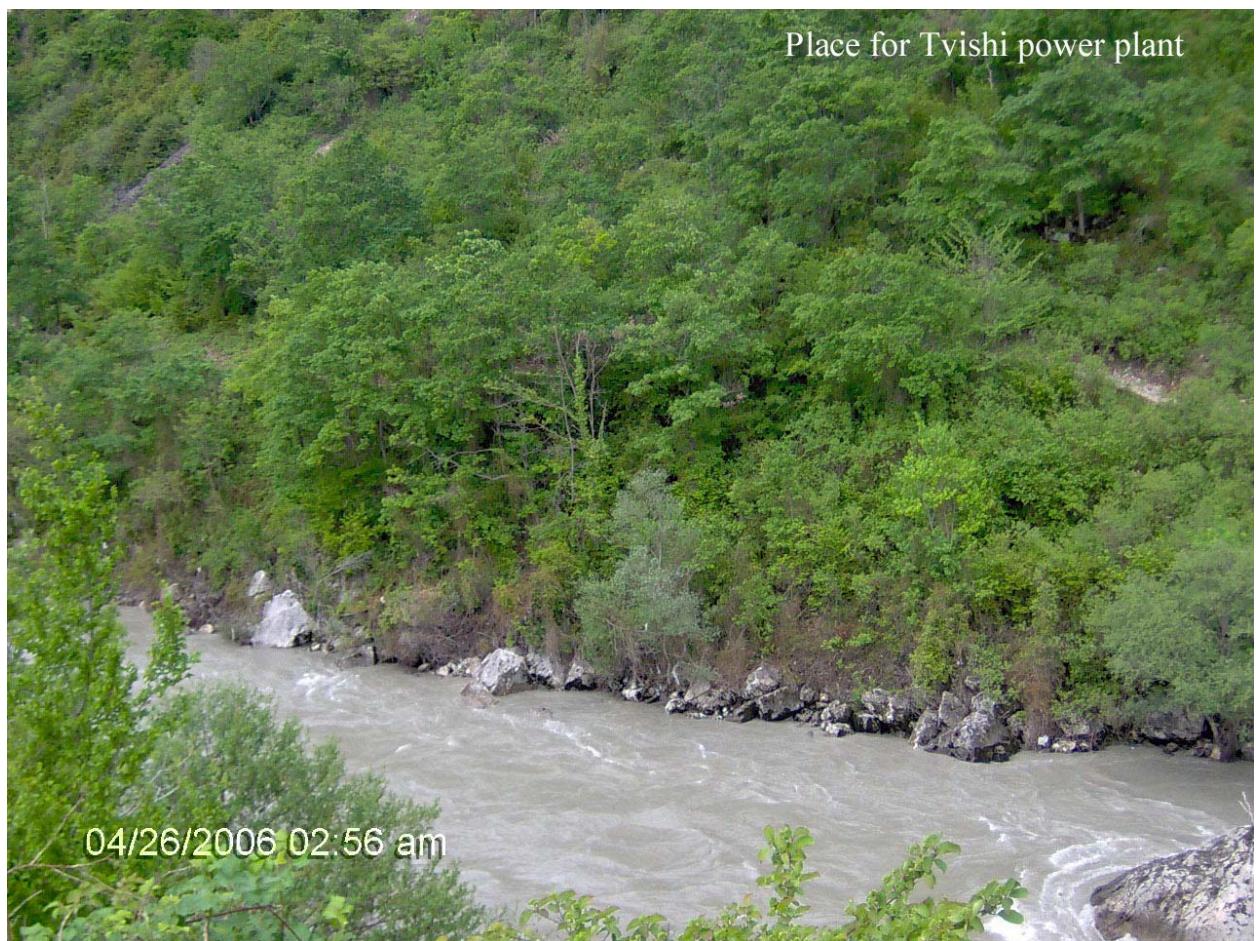
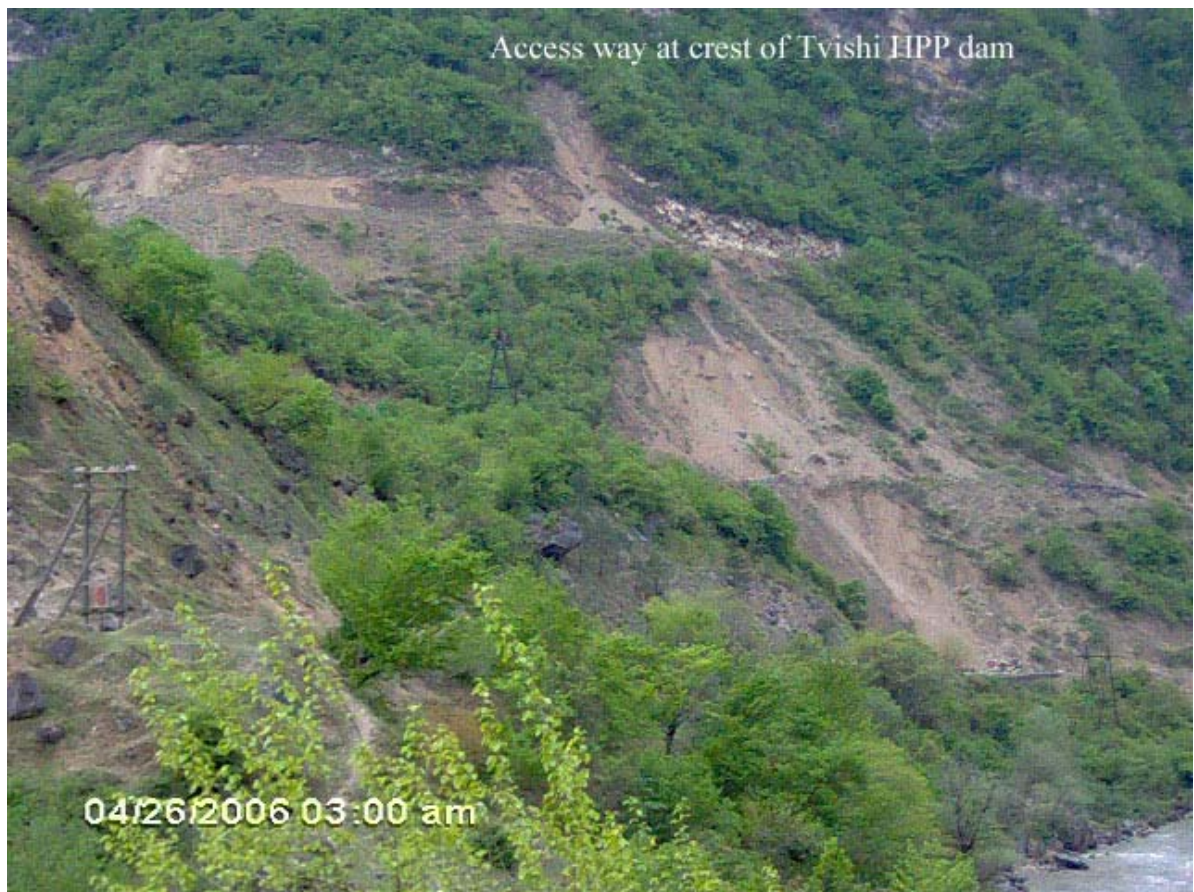
Namakhvani Cascade Operating Cost and Revenue Estimate First 10 years										
	Year:									
	1	2	3	4	5	6	7	8	9	10
A. Capital and Operating Cost Estimation Factors: Operating Costs Per MWH estimated \$ 2.00 Construction cost to be capitalized \$ Millions 600.00 Depreciation Period of construction cost, years 20 Interest Rate on Construction Loan 5.00% Share of Construction cost from Private Capital 50% Desired after tax rate of Return on private share 15% Income Tax Rate 20% Depreciation Method: Flat Annual Depreciation, \$ Millions: 30.00										
B. Additional Assumptions: Domestically Dispatched Output (Annually) 1,031,740 MWH Additional Output Available for Export (Annually) 806,107 MWH Highest Current Tariff of Other Hydro Power Plants 2.78 US Cents/KWH without VAT Lowest Import Tariff 2.90 US Cents/KWH without VAT Net Export Sold at Export Price of 3.50 US Cents/KWH without VAT Value of Export Potential From Plant (Annually) \$ 28.21 \$ Millions										
C. Plant Accounts:										
Net Undepreciated Plant, Start of Year:										
Net Ownership Equity	\$ 600.00	\$ 300.00	\$ 540.00	\$ 510.00	\$ 480.00	\$ 450.00	\$ 420.00	\$ 390.00	\$ 360.00	\$ 330.00
Net Debt After Apply Depreciation to Amortization	\$ 300.00	\$ 270.00	\$ 240.00	\$ 210.00	\$ 180.00	\$ 150.00	\$ 120.00	\$ 90.00	\$ 60.00	\$ 30.00
D. Cost of Capital										
Cost of Equity	\$ 45.00	\$ 45.00	\$ 45.00	\$ 45.00	\$ 45.00	\$ 45.00	\$ 45.00	\$ 45.00	\$ 45.00	\$ 45.00
Income Tax on Equity Earnings	\$ 9.00	\$ 9.00	\$ 9.00	\$ 9.00	\$ 9.00	\$ 9.00	\$ 9.00	\$ 9.00	\$ 9.00	\$ 9.00
Annual Interest Cost of Debt	\$ 15.00	\$ 13.50	\$ 12.00	\$ 10.50	\$ 9.00	\$ 7.50	\$ 6.00	\$ 4.50	\$ 3.00	\$ 1.50
Subtotal, Cost of Capital:	\$ 69.00	\$ 67.50	\$ 66.00	\$ 64.50	\$ 63.00	\$ 61.50	\$ 60.00	\$ 58.50	\$ 57.00	\$ 55.50
E. Annual Operating Costs	\$ 2.06	\$ 2.06	\$ 2.06	\$ 2.06	\$ 2.06	\$ 2.06	\$ 2.06	\$ 2.06	\$ 2.06	\$ 2.06
F. Total Annual Costs	\$ 71.06	\$ 69.56	\$ 68.06	\$ 66.56	\$ 65.06	\$ 63.56	\$ 62.06	\$ 60.56	\$ 59.06	\$ 57.56
G. Expected Revenues at:										
Plant Tariff at Other HPPs Tariff	\$ 28.66	\$ 28.66	\$ 28.66	\$ 28.66	\$ 28.66	\$ 28.66	\$ 28.66	\$ 28.66	\$ 28.66	\$ 28.66
Plant Domestic Tariff at Marginal Cost Tariff	\$ 39.33	\$ 39.33	\$ 39.33	\$ 39.33	\$ 39.33	\$ 39.33	\$ 39.33	\$ 39.33	\$ 39.33	\$ 39.33
Plant Domestic Tariff at Sub-Market Marginal Cost Tariff	\$ 39.33	\$ 39.33	\$ 39.33	\$ 39.33	\$ 39.33	\$ 39.33	\$ 39.33	\$ 39.33	\$ 39.33	\$ 39.33
Plant Domestic Tariff at the Lowest Import Tariff	\$ 29.92	\$ 29.92	\$ 29.92	\$ 29.92	\$ 29.92	\$ 29.92	\$ 29.92	\$ 29.92	\$ 29.92	\$ 29.92
H. Expected Economic Rents or Revenue Deficits at:										
Plant Tariff at Other HPPs Tariff	\$ (42.40)	\$ (40.90)	\$ (39.40)	\$ (37.90)	\$ (36.40)	\$ (34.90)	\$ (33.40)	\$ (31.90)	\$ (30.40)	\$ (28.90)
Plant Domestic Tariff at Marginal Cost Tariff	\$ (31.73)	\$ (30.23)	\$ (28.73)	\$ (27.23)	\$ (25.73)	\$ (24.23)	\$ (22.73)	\$ (21.23)	\$ (19.73)	\$ (18.23)
Plant Domestic Tariff at Sub-Market Marginal Cost Tariff	\$ (31.73)	\$ (30.23)	\$ (28.73)	\$ (27.23)	\$ (25.73)	\$ (24.23)	\$ (22.73)	\$ (21.23)	\$ (19.73)	\$ (18.23)
Plant Domestic Tariff at the Lowest Import Tariff	\$ (41.14)	\$ (39.64)	\$ (38.14)	\$ (36.64)	\$ (35.14)	\$ (33.64)	\$ (32.14)	\$ (30.64)	\$ (29.14)	\$ (27.64)
I. Adjusted Revenues after Including Additional Revenue from Additional Available Capacity Sold at Export Tariffs										
Plant Domestic Tariff at Other HPPs Tariff + Export Sales	\$ 56.87	\$ 56.87	\$ 56.87	\$ 56.87	\$ 56.87	\$ 56.87	\$ 56.87	\$ 56.87	\$ 56.87	\$ 56.87
Plant Domestic Tariff at Marginal Cost Tariff + Export Sales	\$ 67.55	\$ 67.55	\$ 67.55	\$ 67.55	\$ 67.55	\$ 67.55	\$ 67.55	\$ 67.55	\$ 67.55	\$ 67.55
Plant Domestic Tariff at Sub-Market Marginal Cost Tariff + Export Sales	\$ 67.55	\$ 67.55	\$ 67.55	\$ 67.55	\$ 67.55	\$ 67.55	\$ 67.55	\$ 67.55	\$ 67.55	\$ 67.55
Plant Domestic Tariff at Import Tariff + Export Sales	\$ 58.13	\$ 58.13	\$ 58.13	\$ 58.13	\$ 58.13	\$ 58.13	\$ 58.13	\$ 58.13	\$ 58.13	\$ 58.13
J. Adjusted Expected Economic Rents or Revenue Deficits after Including Export Sales at:										
Plant Domestic Tariff at Other HPPs Tariff + Export Sales	\$ (14.19)	\$ (12.69)	\$ (11.19)	\$ (9.69)	\$ (8.19)	\$ (6.69)	\$ (5.19)	\$ (3.69)	\$ (2.19)	\$ (0.69)
Plant Domestic Tariff at Marginal Cost Tariff + Export Sales	\$ (3.52)	\$ (2.02)	\$ (0.52)	\$ (0.98)	\$ 2.48	\$ 3.98	\$ 5.48	\$ 6.98	\$ 8.48	\$ 9.98
Plant Domestic Tariff at Sub-Market Marginal Cost Tariff + Export Sales	\$ (3.52)	\$ (2.02)	\$ (0.52)	\$ (0.98)	\$ 2.48	\$ 3.98	\$ 5.48	\$ 6.98	\$ 8.48	\$ 9.98
Plant Domestic Tariff at Import Tariff + Export Sales	\$ (12.93)	\$ (11.43)	\$ (9.93)	\$ (8.43)	\$ (6.93)	\$ (5.43)	\$ (3.93)	\$ (2.43)	\$ (0.93)	\$ (0.57)

Table 2 – Namakhvani Cascade Operating Cost & Revenue Estimate for the First 10 Years

7. PHOTOS

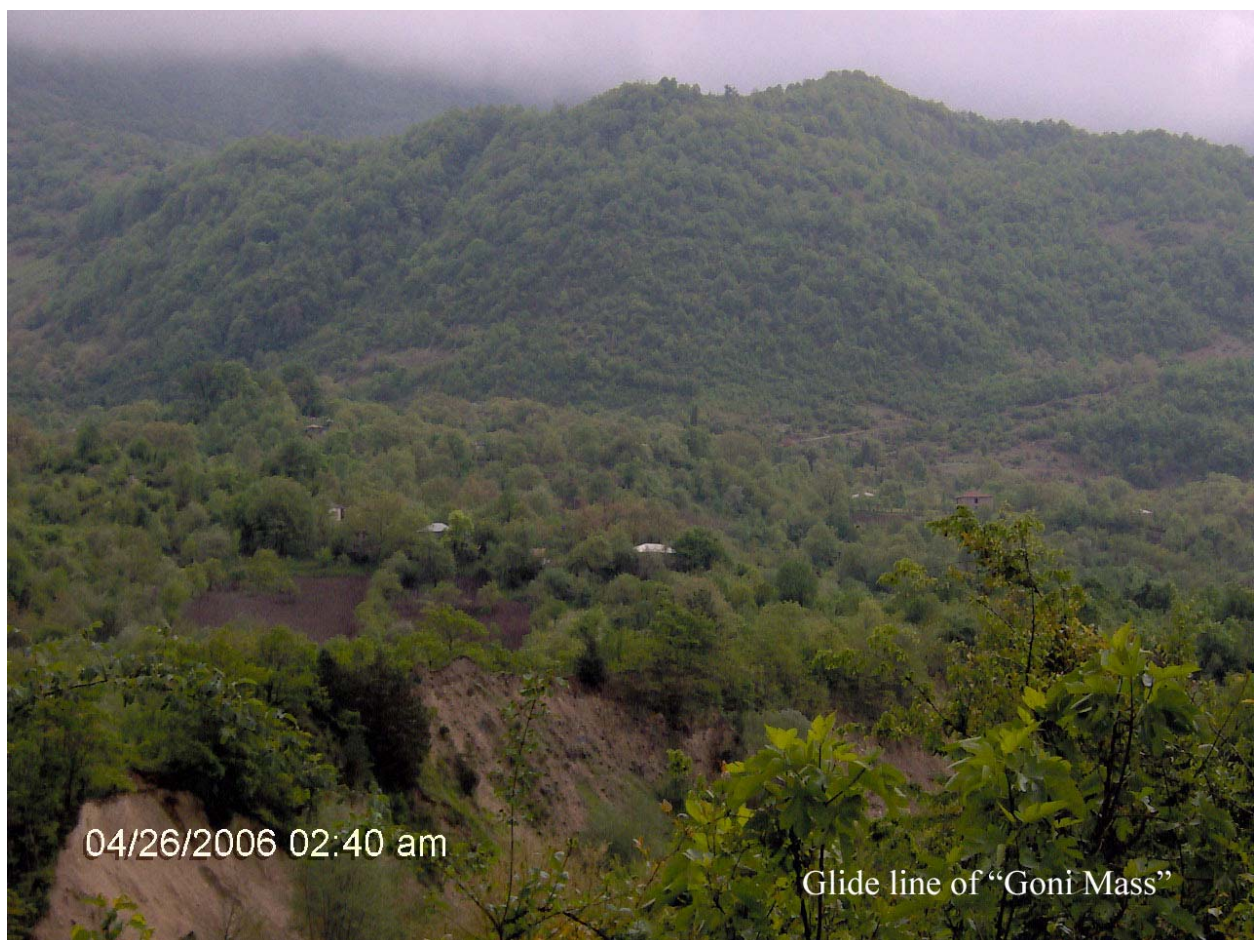
7.1.PHOTOS – Tvishi HPP







7.2.PHOTOS – Namakhvani HPP





Section of Namakhvani HPP arch dam. Left bank abutment



Section of Namakhvani HPP arch dam. Right bank abutment



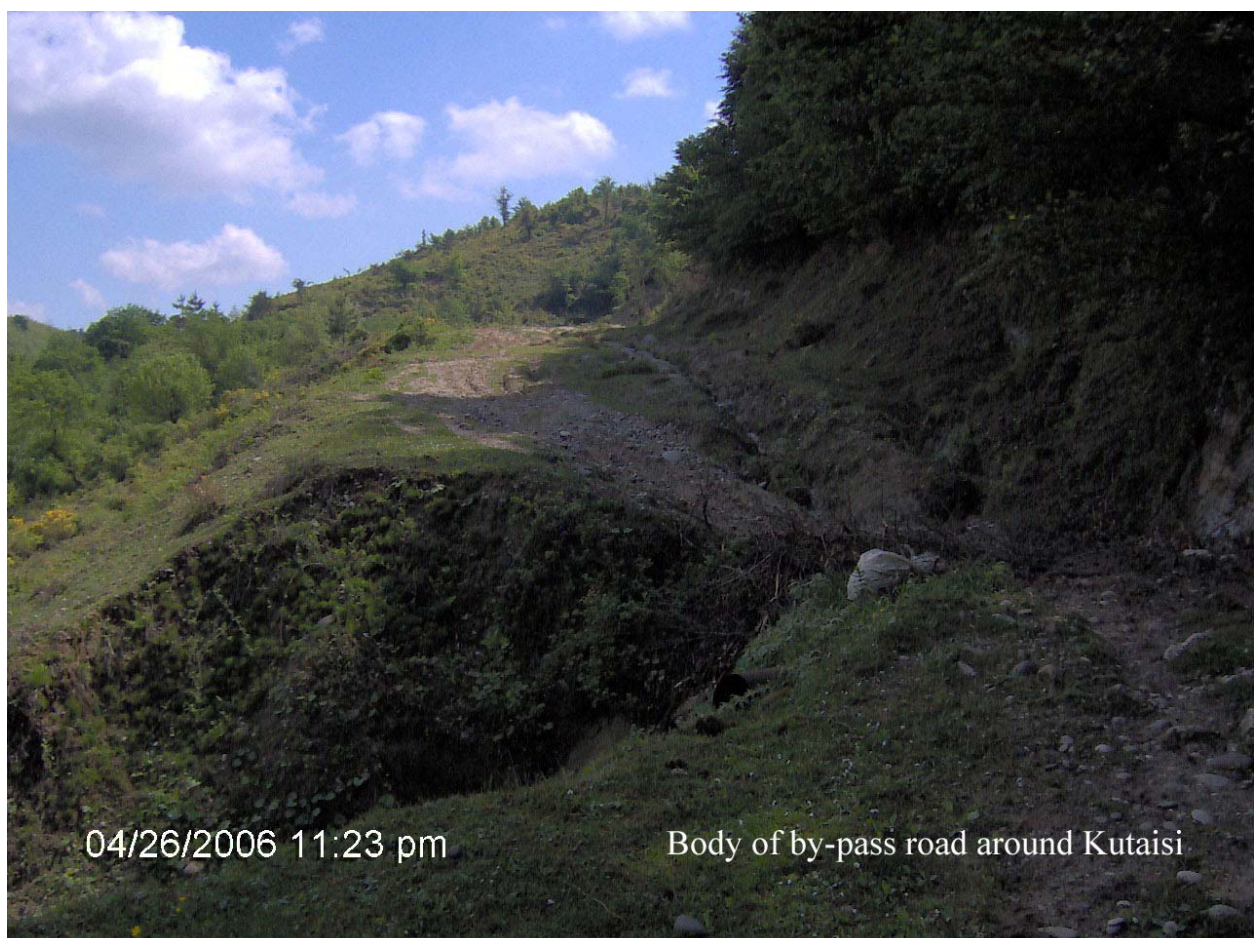
7.3.PHOTOS – Zhoneti HPP



7.4.PHOTOS – Other Supporting Facilities and Roads



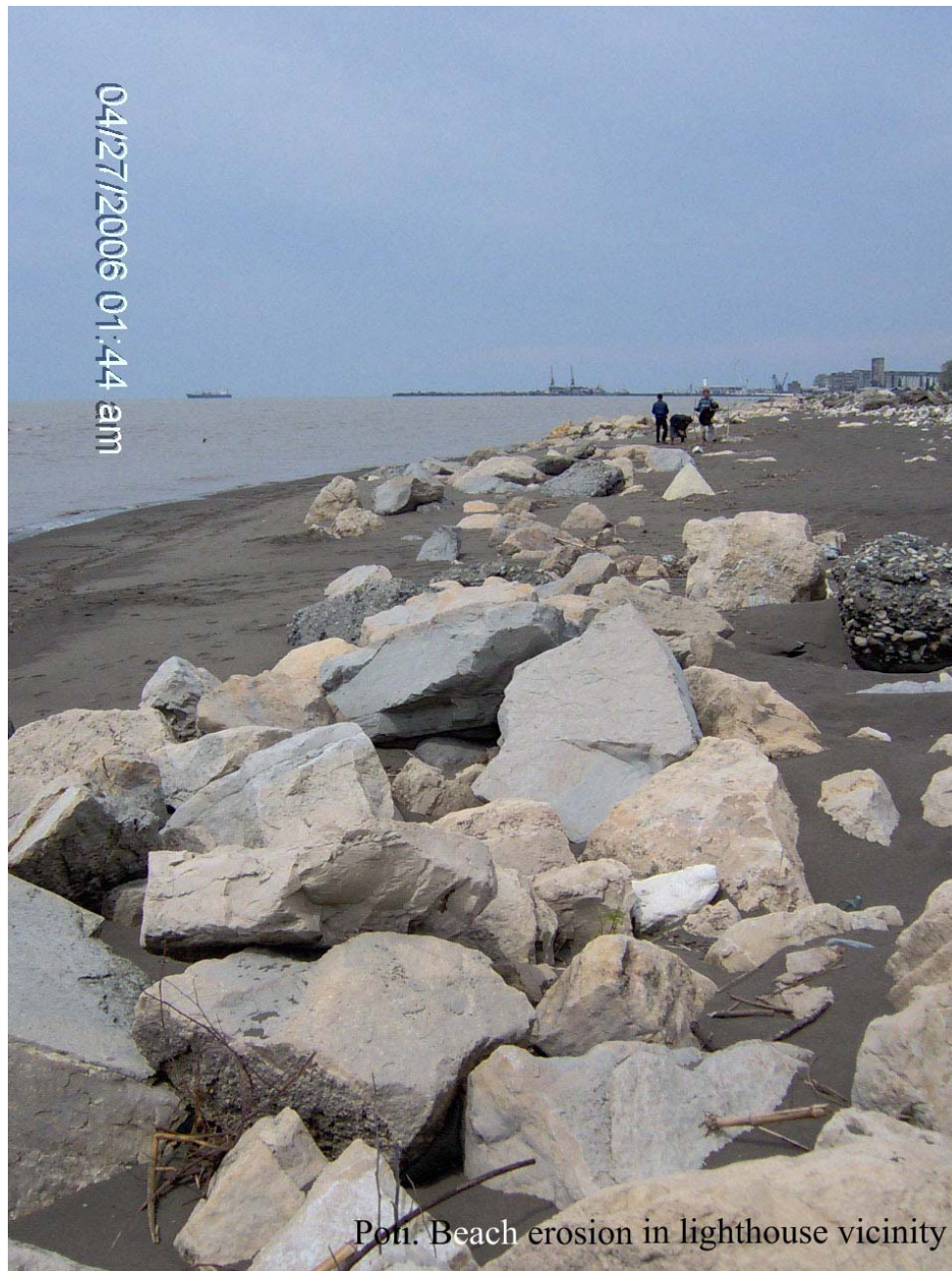




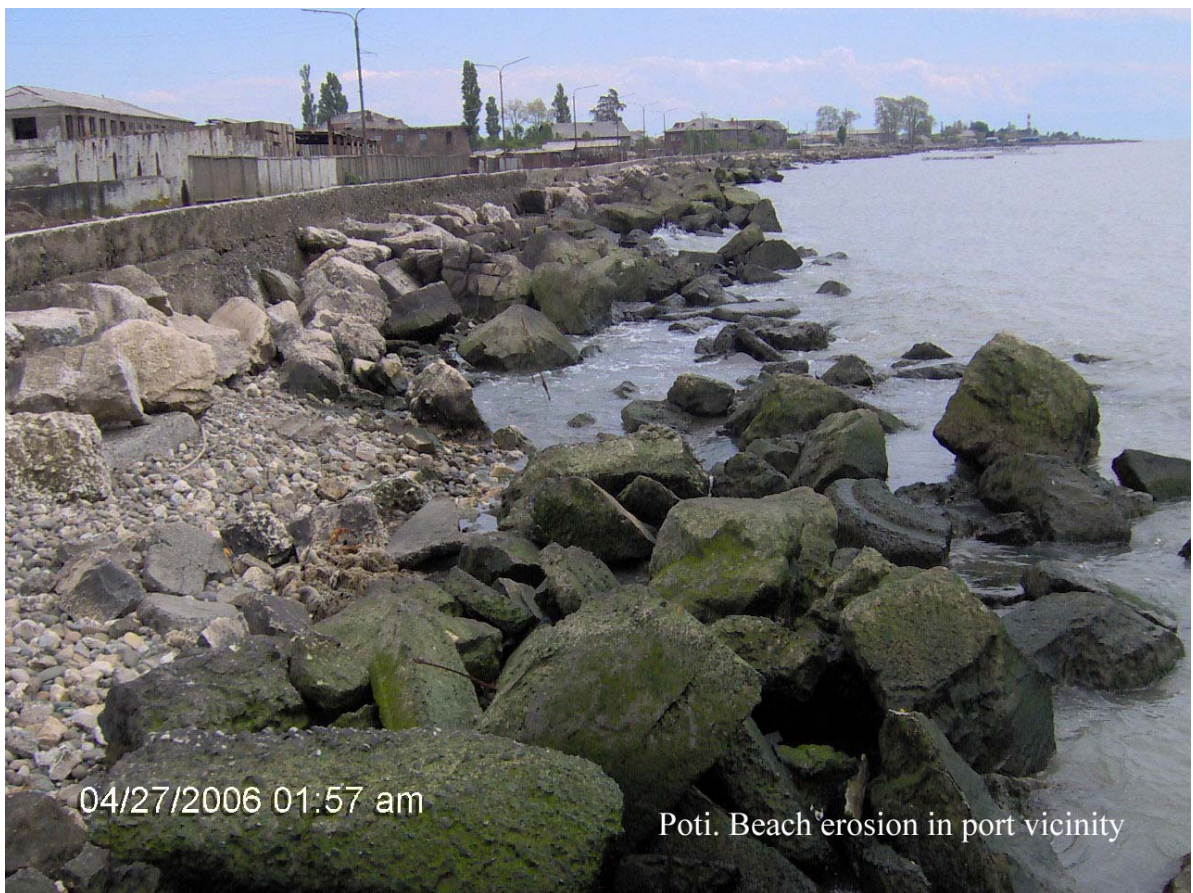




7.5.PHOTOS – Poti Seashore







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APPENDIX 2 – Technical Project Assignment in 1975

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Approval by Cabinet of Ministers - 23.12.1987
Attachment #1 - 23.12.1987
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Project Approval by GosPlan in 1988

Project Approval by Ministry of Energy USSR in 1988

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Copy of Letter #04-400 on Financing the Construction - 21.03.1988

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Part II, SubPart 3, Vol 3 - Engineering-Geodesic Conditions
Part III, SubPart 1, Vol 1 - Water Facilities
Part IV, SubPart 1, SubSubPart 1, Vol 1 - Hydro Structures of Tvishi HPP
Part IV, SubPart 1, SubSubPart 2, Vol 2 - Hydro Structures of Namakhvani HPP
Part IV, SubPart 1, SubSubPart 2, Vol 2, Book 2 - Arch Dam of Namakhvani HPP
Part IV, SubPart 1, SubSubPart 3, Vol 3 - Hydro Structures of Zhoneti HPP
Part IV, SubPart 2, SubSubPart 1, Vol 1 - HydroPower and HydroMechanical
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Part IV, SubPart 2, SubSubPart 2, Vol 2 - Electrical Part
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TVISHI HPP - Power House Vertical Section 3-3
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NAMAKHVANI HPP - Arch Dam Radial Sections - Left Bank
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NAMAKHVANI HPP - Arch Dam's Key Section & Index of Drawings
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NAMAKHVANI HPP - General Plan
NAMAKHVANI HPP - Power House Horizontal Sections 99 & 10-10
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APPENDIX 17b – Environment - Tvishi Vineyards

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Letter from Council of Trade Union's Resorts Management on Water Quality

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